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A
DESCRIPTION
OF
VENTILATORS:

WHEREBY
Great Quantities of FRESH AIR
May with Eaſe be conveyed into MINES, GOALS,
HOSPITALS, WORK-HOUSES and SHIPS,
In Exchange for their *Noxious Air.*
An Account alſo of their GREAT USEFULNESS
in many other Reſpects:
As in Preſerving all Sorts of GRAIN Dry, Sweet, and
free from being Deſtroyed by WEEVELS; both in
GRAINARIES and SHIPS: And in Preſerving
many other Sorts of Goods.
As alſo in drying CORN, MALT, HOPS,
GUN-POWDER, *&c.* and for many other
uſeful Purpoſes.
Which was read before the ROYAL SOCIETY
in *May* 1741.

And God made
The Firmament, Expanſe of liquid, Pure,
Tranſparent, Elemental *Air.* MILTON.

By *STEPHEN HALES* D. D. F. R. S.
Rector of *Faringdon, Hampſhire;*
And Miniſter of *Teddington, Middleſex.*

LONDON:
Printed for W. INNYS, at the Weſt End of St. *Paul's;*
R. MANBY, over againſt the *Old Bailey* on *Ludgate-Hill;*
and T. WOODWARD.
M. DCC. XLIII.

AT a Meeting of the ROYAL-SOCIETY, *June* 9, 1743.

Imprimatur

M. FOLKES, Pr. R. S.

To the Right Honourable DANIEL *Earl of* Winchelſea *and* Nottingham;
The Honourable JOHN COKBURNE *Eſq*;
The Right Honourable Lord ARCHIBALD HAMILTON;
The Right Honourable Lord BALTIMORE;
The Honourable PHILIP CAVENDISH *Eſq*;
The Honourable GEORGE LEE *Doctor of Laws*;
The Honourable JOHN TREVOR *Eſq*;

Commiſſioners for Executing the Office of Lord High Admiral of Great Britain, &c.

MY LORDS,

THOUGH the Subject of this Treatiſe is like to be of great Benefit to Mankind, in many Reſpects; yet as it was at firſt principally intended for the Service of Sea-farers; and as your Lordſhips were pleaſed to encourage and promote the Thing, by ordering a Trial to be made thereof: ſo I thought it not improper, to addreſs myſelf on this occaſion to your Lordſhips, who have the Super-intendency of the Royal Navy.

THERE is no doubt but it will fully anſwer your Lordſhips tender Care and Concern for the Welfare of Navigators, as it will contribute much to their Health, by ſupplying them, in exchange for a very noxious, with Plenty of freſh Air, that genuine Cordial of Life: For that wonderful Fluid the Air, which, by infinite Combinations with natural Bodies, produces ſurprizing Effects, as it is on the one Hand when pure, the chief Nouriſher and Preſerver of the Life of Animals and Vegetables; ſo, when foul and putrid, it is the great Principle of their Deſtruction.

As Sea-farers, that Valuable and Uſeful Part of Mankind, have many Hardſhips and Difficulties to contend with, ſo it is of great Importance to obviate as many of them as poſſible: And as the noxious Air in Ships has hitherto been one of their greateſt Grievances, by making ſick and deſtroying multitudes of them; ſo the finding a Means to prevent this great Evil, is of vaſtly more Conſequence to Navigation, than the Diſcovery of the Longitude; as being a Means of ſaving innumerable more Lives, than that would do. And therefore it was what well deſerved the moſt diligent Reſearches; and even the trying, every the loweſt Degree of Probability of effecting it.

WHEN it is found, that Men can, with greater Safety to their Lives, traverſe the vaſt Expanſe of Waters, it will be a great Advantage to Navigation, and Traffick will thereby be much inlarged.

THAT your Lordſhips have not herein been countenancing a vain fruitleſs Attempt, is evident, not only from conſidering the Effects of the Engine, which exchanges great Quantities of bad, for good Air; but alſo from the Event, it having been found very ſalutary by the *Swedes*, who have made the Trial.

'Tis a good Symptom that we are got upon a right Scent, when it leads not only to the Thing firſt ſought for; but alſo to many other uſeful Diſcoveries, as we ſee this does.

We have here an Inſtance, that the Study of Natural Philoſophy is not a meer trifling Amuſement, as ſome are apt to imagine: For it not only delights the Mind, and gives it the moſt agreeable Entertainment, in ſeeing in every thing the Wiſdom of the great Architect of Nature: But it is alſo the moſt likely Means, to make the Gift of kind Providence, this natural World, the more beneficial to us, by teaching us how, both to avoid what is Hurtful, and to purſue what is moſt Uſeful and Beneficial to us.

I am,

With all due Reſpect,

MY LORDS,

Your Lordſhips

Obedient Humble Servant,

Stephen Hales.

THE PREFACE.

IT *may not be improper to give an Account how I, who am neither concerned nor skilled in naval Affairs, came firſt to think of theſe Ventilators*; viz. *In the beginning of* September *in the Year* 1740, *I wrote to Dr.* Martin *Phyſician to Lord* Cathcart, *General of the Forces which lay imbarked at* Spithead, *for an Expedition in* America, *to propoſe (beſides the uſual ſprinkling between Decks with Vinegar) the hanging up very many Cloths dipped in Vinegar, in proper Places between Decks, in order* *to make the Air more wholeſome: And in caſe an infectious Diſtemper ſhould be in any Ship, to cure the Infection with the Fumes of burning Brimſtone.*

It was from theſe Conſiderations, which often recurred to my Thoughts, that it occurred to me the March *following, that large Ventilators would be very ſerviceable, in making the Air in Ships more wholeſome; this I was ſo fully ſatisfied of, that I immediately drew up an Account of it; ſeveral Copies of which were communicated, both by my ſelf and others, to many Perſons of Diſtinction, and Members of the* Royal Society: *Before whom I laid a large Account of it, which was read in their Preſence the* May *following, as appears by the Minutes of the Society.*

November *the ſixth following*, viz. *in the Year* 1741, Martin Triewald, Captain *of* Mechanicks *and Military* Architect *to the King of* Sweden, *and Fellow of the* Royal Society *at* London, *in a Letter to* Cromwell Mortimer M. D. *and Secretary of the* Royal Society, *ſays, that* "*this Spring* "*he had invented a Machine, for the* "*Uſe of his Majeſty's Men of War,* "*which went to block up* Petersburgh, "*in order to draw out the bad Air* "*from under their Decks, the leaſt* "*of which does exhauſt* 36172 *cu*-"*bick Feet of Air in an Hour,*" *that is at the Rate of* 21732 *Tuns in twenty four Hours.*

It were a very extraordinary Circumſtance, that two Perſons at ſo great a Diſtance from each other, without getting a Hint of it, one from the

This Treatiſe, he ſays, was read before the Royal Academy *of* Sweden *the third day of* April 1742. “ *which noble Work the Academy wiſh to ſee ſoon printed.*” *This was eleven Months after mine was laid before the* Royal Society.

And in his Letter to Baron Waſenberg, *Envoy from the King of* Sweden, *dated the 22d of* April 1743, *which the Baron did me the Favour of communicating to me, he ſays,* “ *that every* Swediſh *Man of War, and Hoſpital-Ship, was laſt Year furniſhed with one of my Engines; which had not been done, in caſe they had not experienced the Benefit of the ſame, the Campaign before that.*” *So that a Trial was made with theſe Ventilators in the Year* 1741, *which proved a very ſickly Summer in the* Swediſh *Fleet,* *except only in the Ship or Ships, which were refreſhed by Ventilators: A ſtrong Inſtance of their great Uſefulneſs; which induced the* Swedes *to put them into every Man of War and Hoſpital-Ship, the Year following.*

And Mr. Triewald *further ſays, that in the Summer of the Year* 1742, *he had ſent one of his Engines, calculated for a Sixty Gun Man of War, to* France; *which being approved of by the* Royal Academy *of* Sciences *at* Paris, *the King of* France *has ordered all the Men of War to be furniſhed with the like Ventilators.*

Being informed, while this Book was printing, that it was ſaid that Nathaniel Henſhaw M. D. F. R. S. *had long ſince made a like Propoſal, for ſweetning the Air of Ships, in a Treatiſe called* Aëro-Chalinos, or a Regiſter *for the Air, printed in the*

Year 1677; *having never ſeen the Book, I ſent for it from the* Royal Society *Library.*

In which Book is the following Propoſal, viz. *In order to have the Benefit of Change of Air, to another Country or Climate, almoſt at any Seaſon, and that without going out of the Houſe; he would have a Room, which he calls an Air-Chamber, to be built about twelve Feet ſquare, and Air-tight every where; with a very large Pair of Organ-Bellows to be placed in the Room; to or from which, Air is to be conveyed through the Wall, by a Copper Pipe; with Valves to open inward or outward, as Occaſion ſhall require. With theſe Bellows, the Air in the Room is either to be condenſed and made heavier, by forcing Air in, or lighter, by conveying Air out of the Room.*

Now, ſuppoſing when the Air is ſo light, as to have the Quickſilver in the Weather-Glaſs fallen to its loweſt Mark twenty eight Inches, that a Perſon ſhould then deſire to be in an Air ſo heavy, as to raiſe the Mercury three Inches higher up to ſettled fair; then the Air muſt be forcibly drove into the Room by the Bellows; and vice verſa *it muſt be drawn out, when it is required to have the Air in the Room ſo much lighter than the outward Air.*

But in both theſe Caſes, the Force of the incloſed Air to puſh out in a condenſed ſtate, or of the outward Air to preſs into the Room, in a rarefied ſtate, would be no leſs than 38304 *Pounds Troy, ſuppoſing the Room to be twelve Feet ſquare every way. And the Force of the Air againſt the Glaſs of the Window, ſuppoſing it to be a*

Foot ſquare, would be 266 Pounds. And the Preſſure of Air on the Bellows, if they were two Feet broad and ſix Feet long, would be equal to 3192 Pounds: for in all theſe Caſes, the Preſſure would be equal to a Quantity of Mercury three Inches deep, and as broad as the ſides of the Room, or ſurface of the Bellows.

He propoſes by this means to cure intermitting Fevers, by having the Air in the Room rarefied in the cold Fit, and condenſed in the hot Fit; during the whole time of which, the Patient is to continue therein: And recommends the uſe of it, among other Diſtempers, to cure the Stone and the Pox.

He propoſes alſo to prevent Sea-Sickneſs thereby, by having a Man thus ſhut up in a cloſe Cabin in a compreſſed Air: This, I ſuppoſe, has led ſome to ſay, that this and my Propo-

ſal are the ſame. But how wide is their Difference! My Ventilators are intended to promote a free Perſpiration and Breathing, by conveying great Quantities of freſh Air into Ships, in exchange for very bad Air. On the contrary, Dr. Henſhaw's *Contrivance would make a good Air, by confining it, very bad, and thereby retard Perſpiration, and incommode the Breathing, and ſo cauſe, inſtead of preventing, Sickneſs: And were his of any real Benefit, it could only be ſo to very few, and that by turns; whereas mine will be beneficial to the whole Ship's Crew at the ſame time. Beſides, the Make of my Ventilators is very different from that of Organ-Bellows.*

I ſhould not have troubled the World with the Recital of this fooliſh Propoſal, had it not been to obviate a falſe Report, which might have prevailed

vailed much more, eſpecially conſidering that the Book itſelf, which refutes it, is now grown ſcarce.

As theſe Ventilators are like to prove of great Benefit to Mankind, in many other Reſpects than are here mentioned, or can as yet be thought of; ſo it will be of great uſe, if thoſe who ſhall have made farther Improvements, will, from time to time, communicate them; as alſo an Account of the Difficulties or Succeſs they have met with in putting the Things here propoſed in execution.

ERRATA.

PAGE 5. penult. for Z. r. N. p. 13. l. 14. r. 326. p. 17. l. 10. for *Pumps* r. *Damps*. p. 50. l. 2. for *when* r. *where*. p. 54. l. 24. for *Holds* r. *Folds*. p. 66. l. 9. r. C. B. p. 73. l 8. r. *ſame Manner*. p. 141. l. 14 r *deducting*.

A
DESCRIPTION
OF
VENTILATORS, &c.

(I.)

1. BEING informed, how very Offenſive the cloſe confined Air in Ships was, and that chiefly where there were a great number of Men, as in Men of War, and eſpecially, in Tranſport and Hoſpital Ships; it occurred to me, that this Inconvenience might, in a great Meaſure, be obviated by means of large Bellows, either ſuch as are made for Organs, which move on a Joint on one end, or elſe are made ſquare or round, like what are called lantern Bellows, which are raiſed and compreſſed on all ſides,

being Cubes or Cylinders, capable of being lengthened or compreſſed. The firſt Sort ſeems to be the moſt commodious for theſe Purpoſes; but they may be made of any ſhape, as ſhall be found beſt to ſuit the Place where they are to be fixed.

2. AND whereas Smiths Bellows and Organ Bellows are heaved with Labour, becauſe in them it is neceſſary to have the Air much compreſſed, that it might paſs with Velocity and Force through ſmall Orifices, it is propoſed therefore to have the Valves and Paſſages through theſe Bellows very large, on which account they will be worked to and fro, with the greateſt Eaſe imaginable, as is evident in the caſe of common Bellows, which will move up and down, with ſurprizing Eaſe, if their Valve be held open with a Finger. And the Caſe would be juſt the ſame, if the Bellows were very large, provided the Valves were proportionably large, and are alſo made to open and ſhut eaſily. For in this Caſe we only want to move a quantity of light uncompreſſed Air, from the outſide to the inſide of the Place where it is deſired, or from within outward.

And ſince a Tun or forty Cubick Feet of Air in bulk, weighs but 300 Grains, which is not three quarters of an Ounce; ſuppoſe a Pair of Bellows were ſo large, as to contain a Tun, yet that Tun of Air would give little reſiſtance to the contracting Bellows, provided the Valves and Wind-Pipes leading to and from them, were proportionably large: And for the ſame Reaſon, the Dilatation of the Bellows would be equally eaſy. Thus we breathe to and fro through a large Wind-Pipe, about ſixteen Tuns of Air in twenty-four Hours, with little or no Labour. And in this conſiſts the peculiar Excellence of this Contrivance; this Method of conveying Air being moſt ſimple, and analogous to the way which Nature makes uſe of, to convey freſh Air into the Lungs of Men, and of many other Animals, *viz.* by the eaſy riſing and falling of the Midriff.

3. Now in order to make trial of the Method here propoſed, I cauſed two Pair of Bellows to be made in the following manner; *viz.* being accommodated with a Grainery, by the Favour of Governour *George Pit* Eſq; at the Houſe of *Anthony Duncombe* Eſq;

which was thirty Feet long, and contained about two hundred Tuns of Air; in the leſſer adjoining Room, were placed, ſide by ſide, two large Boxes, which were ten Feet long, five Feet wide, and two Feet deep, in the clear within ſide. *Fig.* 1. A B C D, deſcribes one of the Boxes, in the middle of which was fixed a broad Partition or Midriff, which was made to move up and down from A to C, on the Hinges X, by means of the Iron Rod Z R, which was fixed to the Midriff at Z, and paſſed through a ſmall Hole in the Cover of the Box up to R; the like Partition, or Midriff, was in the other Box, with its Iron Rod Z R; which two Rods were fixed to a Lever or Arm F, G, *Fig.* 2. which moved on the fixed Centre O: So that by the alternate raiſing and preſſing down of the Lever F, G, the Midriffs were alſo alternately raiſed and depreſſed, whereby theſe double Bellows were, at the ſame time, both drawing in Air and pouring it out; one of each Pair of Bellows, being in a dilating ſtate, drew in the Air; while the other two, which were at the ſame time in a compreſſing ſtate, blew it out. And that the Midriffs might be the lighter, they were made of four Bars or Rails length-wiſe, and as many acroſs them breadth-wiſe, which were each three Inches broad and an Inch and quarter thick, ſwelling in the middle to give them Strength. The vacant Spaces were filled up with thin Pannels of Fir Board, like Wainſcot Work.

4. THE Midriff Z X moving to and fro with its Edges very near, *viz.* $\frac{1}{10}$th of an Inch from the ſides of the Box A, B, C, D, F, E, *Fig.* 1. very little Air, in compariſon of the whole, will eſcape by the Edges; ſo that there will be no need of leathern ſides, as in common Bellows: which Leather would not only be more expenſive, but would alſo cauſe them to move much more heavily. And, that the Midriffs may move to and fro with the greater Eaſe, and without touching the ſides of the Boxes, there is an Iron-Regulator fixed upright, *Fig.* 1. to the middle of the end of the Box A C from N to L; which being half an Inch thick, and an Inch broad, a Notch of the ſame depth is cut into the middle of the End of the Midriff at Z, ſo that the Midriffs in riſing and falling, ſuffer no other Bearing or Friction than what

is made between the *Regulator* and the Notch.

5. THE end of the Box at A C muſt be made a little circular, that it may be the better adapted in all Parts, between A and C to the riſing and falling Midriff; and if the Boards at this end of the Box be but half an Inch thick, ſuch thin Boards will, on being nailed on, the more eaſily comply with, and be forced into the circular Shape of, the Ends of the Side-Boards to which they are nailed. And that theſe Boards might the better retain their circular Shape, circular Battings were nailed on their outſide: But in the Ventilators on ſhipboard, for the ſake of greater Strength, this circular Form was cut out of a thick Fir-Plank. At the other end X of the Midriff a ſlip of Leather may be nailed over the Joint at the Hinges, if needful. The Hinges were made of two pieces of Iron, one of which graſped the End of the Midriff at the ſide, the other was a flat piece of Iron ſix Inches long, one and a half broad, and half Inch thick, which was let into the Side-Board of the Ventilators; theſe two Irons were riveted together with a Rivet half Inch thick, which was the moving Joint.

6. All the Boards of which the Boxes are compoſed ought to have their Joints well ſecured with *Grooves* and *Tongues*, and have brown Paper paſted over them; and eſpecially near both the Ends they may be faſtned with Wood-Screws, to draw out, in order to rectify any thing that may be amiſs there.

7. The eight large Valves for the Air to paſs through were placed at the Hinge-End of the Boxes B K, *Fig.* 2. 1, 2, 3, 4, 5, 6, 7, 8. The Valve, Numb. 1. opens inward to admit the Air to enter, when the Midriff is depreſſed at the other End, by means of the Lever F G. And at the ſame time the Valve 3, in the lower Ventilator, is ſhut by the compreſſed Air which paſſes out at the Valve 4. But when that Midriff is raiſed, then the Valve 1 ſhuts, and the Air paſſes out at the Valve 2. And it is the ſame with the Valves 5, 6, 7, 8, of the other Box; ſo that when by the Motion of the Lever F G, the Midriffs are alternately riſing and falling, then two of the Ventilators are conſtantly drawing in Air, and two of them

at the ſame time are blowing it out at their proper Valves; the Air entering at the Valves 1, 3, 6, 8, and paſſing out at the Valves 2, 4, 5, 7.

8. THERE was fixed to the Ventilators before the Valves 2, 4, 5, 7, a Box Q, Q, N, M, *Fig.* 3. as a common Receptacle for all the Air which came out of thoſe Valves; which Air paſſed off thro' the Trunk P, which was a Foot ſquare in the Clear within; this Trunk paſſed thro' the Partition-Wall of the two Rooms. The Valves were hung on Leathern Hinges, which were fixed to their upper Side, which is beſt, becauſe that Poſition will cauſe them always to ſhut of themſelves by their own Weight. In Ships theſe Hinges ought to be made of Braſs or Copper, to prevent ruſting.

9. I MADE the Openings of the Valves at firſt, twelve Inches long and ſix wide, which was one hundredth part of the Breadth of each Midriff, they being fifty ſquare Feet broad; but on trial, I found theſe Openings too narrow for the great Quantity of Air which was to paſs thro

them. I then made the Openings two Feet long, and ſeven Inches wide; which I found to be a ſufficient degree of wideneſs, that being nearly $\frac{1}{44}$th part of the Breadth of each Midriff: which were moved up and down eaſily enough, notwithſtanding each of them weighed on the Lever at RR, *Fig.* 2. thirty Pounds; which very little increaſed the Force requiſite to move the Lever, becauſe they counter-balanced each other's Weight: on which account two Pair of theſe Bellows, in this horizontal Poſture, may be worked with more eaſe than one Pair.

10. It is very requiſite to make the Valves as light as poſſible; for when they weighed two Pounds, being made of red Fir half Inch thick, they did not open wide enough for the Air to paſs freely. But when they were made about $\frac{1}{4}$th Inch thick, and of lighter white Fir, weighing but fifteen Ounces; being then raiſed, by the ruſhing Air, to an Opening of about forty-five Degrees, or half open; then the Midriffs were worked to and fro with eaſe enough. But to prevent the warping of theſe thin Valves, it was needful to let in, tack and glew on

them, Pieces or Fillets acroſs each of them, *viz.* one at each End, and one in the Middle. It will contribute much to their Lightneſs, to have the lower more moveable part of the Valves much thinner than the upper part; which will require a thicker Subſtance of half an Inch, to nail the Hinges faſt on; which, if made of Horſes Hides, will be very tough and durable.

11. IF it were needful to make the Valves open wider, with more eaſe, it might be done by placing a Counter-balancing Weight, ſo as to make them ſhut with only one fourth Part of their Weight, or leſs, as I have found on Trial may be done: but there ſeems no need to make them go ſo very eaſy; tho' the Reſiſtance that there is, is principally from the Valves: for when they are all ſet open, the Midriffs are moved up and down with much more Eaſe.

12. WHEN the Box QQ, with its Trunk P, was put over the Valves 2, 4, 5, 7. *Fig.* 2, and 3. ſo as to receive the Air which ruſhed out of them; then the Midriffs required a ſenſibly greater Force to move

them up and down: which ſhows that the Trunk P was not wide enough, notwithſtanding it was a Foot ſquare in the Clear within ſide. Whence I found, that the working of the Bellows, faſter than at the Rate of ſixty Strokes in a Minute, did not proportionably increaſe the Quantity of Air that was conveyed out of them: for when they worked at the Rate of eighty Strokes in a Minute, the Air not being able to paſs off ſo faſt at the Noſe, was much compreſſed in the Bellows; which Air dilating again as the Bellows dilated, ſo much the leſs Air was ſucked in at each Dilatation of the Bellows, and conſequently ſo much the leſs paſſed off. Which is a Thing well worth the taking notice of, elſe there may be much ſuperfluous Labour, when the Bellows are worked too faſt, for the Air to paſs as freely and faſt off: for when the Bellows are large, they will convey great Quantities of Air, without being worked very faſt, which will much leſſen the Labour of working them.

(II.)

13. IT is eaſy to make an Eſtimate of the great Quantities of Air, that are conveyed by theſe Bellows: For ſuppoſe the Midriffs riſe and fall one Foot at each Stroke, which is enough, and that ſixty Times in a Minute, that will amount to ſeventy-five Tuns in a Minute, and four Thouſand five Hundred in an Hour; which will amount to one Hundred eight Thouſand Tuns in twenty-four Hours. And the Trunk P being a Foot ſquare, the Velocity of the Air, as it paſſes out thence, will be at the rate of three Thouſand Feet in a Minute; which is at the rate of thirty-four Miles in an Hour. This, ſuppoſing no Air eſcaped between the Edges of the riſing and falling Midriffs, and the Sides of the Boxes, for which, an Allowance is to be made; for which, ſuppoſing eight Miles are deducted, a large Allowance; That will be nearly the Velocity with which a Race-Horſe goes, who runs four Miles in nine Minutes, which is at the rate of 26.6 Miles in an Hour. And more than

thrice the Velocity with which Fans impel Air, in winnowing Corn, when they are turned at the Rate of ſeventy Revolutions in a Minute.

14. MONSIEUR MARIOTTE found that a pretty ſtrong Wind moves twenty-four Feet in a Second of Time, which is at the Rate of one Thouſand four Hundred and Forty in a Minute; that is, at the Rate of Twelve and a half Miles in an Hour: which is about half the Velocity, with which the Wind ruſhes out of theſe Ventilators.

15. IN my *Statical Eſſays*, Vol. II. pag. 330. it was found that the Air ruſhed out of a Pair of Smith's Bellows, at the Rate of 68.73 Feet in a Second of Time; that is, at the Rate of Seventy-eight Miles in an Hour, when compreſſed with a Force equal to the Weight of one Inch perpendicular Depth of Mercury, laying on the whole upper Surface of the Bellows.

16. BUT there is another Way whereby to eſtimate the Velocity, with which im-

pelled Air paſſes out at any Orifice: this I tried by hanging a light Valve, which was ſix Inches long, and three and a half broad, over the Noſe of the Bellows, by pliant Leathern Hinges, which was agitated and lifted up much, from a perpendicular to a more than horizontal Poſition, by the Force of the ruſhing Air. Whereas in another ventilating Machine, compoſed of a Wheel with Fans, in a Drum, ſuch as is deſcribed in *Agricola de Re Metallica*, and in the *Philoſophical Tranſactions*, a like Valve was moved very little, by the Force of the Air which it conveyed; which evidently ſhews the great Difference there is, in the Velocities, and conſequently the Quantities of Air that are conveyed by theſe Machines. There is another more accurate Way of eſtimating the Velocity of Air, *viz.* by holding the Orifice C of an inverted Glaſs Siphon or Crane full of Water; ſuch as is deſcribed, *Fig.* 9. C R I, oppoſite to the Stream of Air, whereby the Water will be depreſſed in the Branch C R, and raiſed in the other Branch I, in proportion to the Force with which the Water is impelled by the Air. When this Crane was applied to the Wheel Ventilator, the Force of the Air, which was ſufficient to blow out a Candle, moved the Water in the Crane very little: whereas when the ſame Crane was applied to the Noſe P of the great Ventilators, *Fig.* 3. the Water was ſo much agitated, that it made large Vibrations up and down in the Crane.

17. Now as to the Velocity of this Wind, it is to be conſidered, that as the ſpecifick Gravity of the Air, is to that of any other Fluid, ſo reciprocally is the Square of the Space, which that Fluid moves in any given Time, to the Square of the Space which the Air, by the ſame Impulſe, will move in the ſame Time. And the ſpecifick Gravity or Weight of Water, being to that of Air as Eight Hundred eighty-one to One, conſequently the Air moves thirty times faſter than Water would do with the ſame Impulſe.

18. According to the different Poſition of the Valves, theſe Bellows may be made, either to convey good Air into a Room, which would drive out the bad

Air at ſome proper Places, or to draw the rancid Air out of a Place, which would be ſucceeded by good Air.

19. I FILLED the Room in which theſe Ventilators were, with the Smoke of wet Hay and Shavings; and then, having firſt conveyed away the ſmoking Fewel, on working the Bellows, the Smoke was in a few Minutes conveyed thro' the Ventilators out of the leſſer Room into the larger Room: Hence we ſee how effectually they will purify the Air in a Room.

20. I FOUND that a Handkerchief held near the Noſe of the Ventilators, waved and was agitated to and fro very briskly; and a Candle was not only inſtantly blown out there, but even at twenty five Feet diſtance, its Flame was blown ſide-ways; and the Agitation of the Air was manifeſtly to be felt at that Diſtance.

21. WHEN it is required to convey great Quantities of Air into Mines, or Magazines, or in drying Malt or Hops, *&c.* theſe Ventilators, whether in an horizontal Poſture,

as in *Fig.* 2. or ſtanding upright as in *Fig.* 4. may be worked by a Horſe, or Stream of Water, turning a Crane, by means of Cogg-Wheels; the Deſcription and Manner of doing of which, may be ſeen in Number (197, *&c.*) and *Fig.* (11.)

22. WHEN freſh Air is to be conveyed into a Mine, or bad Air to be drawn out of it, for one or the other of theſe is to be done, according as the noxious Pumps are ſpecifically lighter or heavier than the common Air, then the Box QQ, *Fig.* 3. is to be fixed over the Valves, 2, 4, 5, 7, with the Trunk P, which is to be continued down by additional Tubes, or Trunks, to the fartheſt Part of the Mine. And perhaps in ſome caſes it may be adviſable to cloſe up the Air-Shaft, at the top, with Boards and ſometimes at its bottom too, when it is needful to convey Air thence by large Trunks to ſeveral Branches and Corners of a Mine. There is in *Agricola de Re Metallica*, not only a Deſcription of the above-mentioned Wheel with Fans in a Drum, but alſo of large Bellows, which are moved by Water or Horſes, to convey Air into

Mines: but as theſe Bellows are made like the Bellows at Iron Forges, with leathern Sides, they will move much heavier than theſe with Midriffs, which convey Air both riſing and falling, which the others cannot do.

23. When there is occaſion to convey much greater Quantities of freſh Air into any Place than the Ventilators, *Fig.* 2. can convey, that may eaſily be effected, by having ſeveral of the like Ventilators lying on each other, whoſe Midriffs may all be moved up and down, by the ſame prolonged Iron Rods R Z, *Fig.* 2.

24. When the Ventilators lie horizontally, as in *Fig.* 2. then it will be beſt to have two Pair of them, becauſe they will work much eaſier than one Pair, on account of the Weight of the Midriffs, which in *Fig.* 2. counter-balance each other, on the Balance R O R; whereas one alone would burthen the Perſon who moves it, with its Weight of thirty Pounds.

25. But if the Bellows are placed in a perpendicular upright Poſture, ſo as to have the End Z uppermoſt, as in *Fig.* 4. then, as the Weight of the Midriff would reſt on its bottom, only one Pair of Bellows may be uſed, and thoſe larger or ſmaller, as ſhall be needful. If the Ventilators are fixed in this upright Poſture, it will be requiſite to place them upon the Box B K L M, as in *Fig.* 4. for the more commodious conveying the Air from them; the manner of doing which is expreſſed in *Fig.* 5. where the End of the ſame Box B L T, is covered with the Board X Z, with two large Holes at X and Z, cut in it for the Air to paſs down thro' X, when the Air in the Side X of the Ventilators is compreſſed by the Midriff; and thro' the other Hole Z, when by the Return of the Midriff the Air of Z is compreſſed. In the other half of the Box Q K M the Board X Z is taken off, to ſhew the manner of the Paſſage of the Air from the Holes X Z, thro' the Paſſages Y, X, V, where Valves are fixed, to prevent the returning back of the Air, which goes out at the Noſe T Q. The Partition R R is neceſſary

to prevent the Air's aſcending up thro' X, while it deſcends thro' Z, and *vice verſâ.* The Air is drawn into theſe Ventilators at the large Valves N N.

26. WHEN it ſhall be requiſite to convey Air into ſome of the Windings and Turnings of Mines, or to the Corners of large Rooms, as in Magazines, *&c.* this may eaſily be done by means of large round or ſquare Trunks, made of Board or Tarpawlins, which may be diſtended by Hoops or Poles. Such Trunks will be lighter than if made of Boards to move to and fro, eſpecially near the Places where the Miners are digging.

27. MINERS obſerve in digging a Well or Shaft, that by having a long Trunk in it, the Air deſcends in a ſufficient Quantity, to make the Air in the Well fit to breathe in. The ſmall Ventilators deſcribed in Numb. (74.) will be very ſerviceable, when the Air of Wells is noxious.

28. IN *Lowthorp*'s Abridgment of the *Philoſophical Tranſactions*, Vol. II. p. 375.

there is an account of four ſorts of Damps obſerved by the Miners in *Derbyſhire:* The firſt is called the common Sort, perceived at firſt by the Candles burning orbicular, and the Flame leſſening by degrees; the Effects of it upon human Bodies are Faintings, Convulſions, Suffocations. The ſecond is what they call the *Peaſe-bloom Damp*, which the Miners imagine, is the Steam of a Vegetable growing lower than the Level. The third is the moſt noxious; the Miners ſay they ſee in the higheſt part of the Roof, in thoſe Paſſages which branch out from the main *Groove*, a round thing of the Bigneſs of a Foot-ball, with a Film or Skin about it, which when broken by Accident, diſperſes it ſelf, and ſuffocates all the Company. The fourth is the *fulminating Damp*, reſembling in its Nature and Effects, Gunpowder, or that Matter which produces Thunder. When this takes fire, it kills by Exploſion, as Thunder and Gunpowder. The Remedies of the Miners, are by Air-Shafts, and Perflation, with artificial Wheels and Bellows. The Air-Shaft is uſually a good diſtance from the *Groove*, thro' which things are conveyed up and ſick Room, thro' the Pores of large Trunks, made of looſe-woven Canvas; which Trunks might reach the whole Length of the Rooms, and be placed at the greateſt diſtance from the Sick, near the Cieling.

31. AND perhaps a like Ventilation of warm dry Air from the adjoining Stove, with a cautious Hand, might be of ſervice to Trees and Plants in Green-Houſes, where it is well known that an Air, full of the rancid Vapours, which perſpire from them, is very unkindly to them, as well as the frowzy Vapours of human Bodies are to Men. For I have ſhewn in my *Vegetable Staticks*, that freſh Air is as neceſſary for the healthy State of Vegetables, as of Animals.

(V.)

32. AS to the Caſe of Ships, where freſh Air is of the utmoſt importance, but Room very ſcanty on account of the great Croud and Cumber of Perſons and Things on board, it was more difficult to find a commodious Place where to

fix the Ventilators. Dr. *Lee* having heard of them, he firſt, and then the reſt of the *Right Honourable the Lords Commiſſioners of the Admiralty*, were pleaſed to ſend for me, to be further informed about them; and thereupon were pleaſed to order, the Maſter Ship-Wrights, and other Officers of *Woolwich* and *Deptford* Yards, to conſider of the moſt commodious Place where to fix them in a Ship. Which was judged to be under the fore Part of the *Orlop* or loweſt Deck, next to the Carpenter's Room. And accordingly they were fixed there, between the main Beams of the *Orlop*, on board his *Majeſty*'s Ship *Captain*, a ſeventy Gun Ship; with their Valve-end and Noſe next to the ſide of the Ship.

33. THEIR Dimenſions being, in proportion as expreſſed in *Fig.* 2. ten Feet long, and each four Feet three Inches wide, in the Clear within ſide; and thirteen Inches deep; one Inch of which being occupied by the Midriff, there remained a Foot depth, for it to riſe and fall in.

34. THE Midriff was made of Fir

Wainſcot Work, with thin Pannels of Wood grooved into four Rails, which run lengthwiſe, and as many acroſs, which were tenanted into each other; the long Rails were four Inches broad, and an Inch thick at each end, ſwelling gradually, to full half an Inch thickneſs more at their middle, thereby to give them greater Strength; the Rails which went acroſs at each end were ten Inches broad: In theſe, about ſix Inches from the ends of the Midriffs, were fixed the Iron Rods Z R, *Fig.* 2. being faſtened there with a Screw and Nut, on Iron Plates on the upper and lower ſide, which were four Inches broad, thereby to ſecure the Wood of the Rail from galling and wearing. The Iron Rods R Z, *Fig.* 2. which were flat at their upper Part, being an Inch and half broad and half Inch thick, with ſeveral Holes, whereby to pin them faſt, into Mortices R. R. of the Lever F G, were, from below the Lever, about three quarters of an Inch ſquare in Subſtance down to Z, where they entered into the ſquare Iron Socket T Z, into which they were faſtened by an Iron Key I; by taking out of which Key, the Iron Rods R R, with the Lever F G, and the middle

Poſt O, might be removed, or unſhipped as they term it, in time of Action, if required: Nothing of it remaining above the Surface of the Ventilators or Floor of the *Orlop*, but about two Inches length of the Iron Socket Z, wherein to faſten the Rods R R again, with the Lever F G, which was twelve Feet long. The lower part of the Iron T Z had a Joint near the Midriff, like two Links of a Chain, or two Eyes in each other, whereby the Rod Z R readily complied at that Joint, which the double Motion cauſed by the riſing and falling of both the Midriff and the Lever. The Hinges on which the Midriffs moved at their other ends, were made as deſcribed in Number (5.)

35. THE outſide Fir-Boards of the Ventilators were an Inch and half thick, as alſo that in the middle between them which was common to both; the circular Board C, D, D, was a thick Fir-Plank. The Openings of the Valves 1, 2, 3, 4, *&c.* were ſix Inches deep, and twenty two Inches long; the Valves themſelves, which hung on Copper Hinges, to prevent ruſting, were an Inch broader and longer; and their Borders, as

well as the correſponding Borders of the Valve Holes which they fell againſt, were lined with a Liſt of Woollen Cloath, both to prevent their making a noiſe, and to ſave them from being broken by falling on hard Wood.

36. THE Valves being each ſix Inches deep, the Partition between them four Inches, and the Spaces above and below them each three Inches, in all twenty two Inches; it was neceſſary to make the Ventilators thus deep at this end, for near two Feet length, both that there might be room for Valves of ſuch a Depth as was neceſſary; and alſo that the Valves, which draw in Air, *viz.* 1, 3, 6, 8, might have full room to move inwards. And that there might be room for the upper Valves 1, 6, to move freely inwards, it was neceſſary to place the upper Surface of the Midriffs, eight Inches below the upper Cover of the Ventilators, leaving only four Inches clear, for the Air to paſs between the Midriffs and the Bottom of the Ventilators.

37. IT was alſo neceſſary to have the

Valve Box Q M M twenty two Inches deep, and eighteen Inches broad from Q to N, not only that there might be room for the Valves, 2, 4, 5, 7. to open, but alſo as much more room beyond the reach of the open raiſed Valves, for the Air to paſs thro' the Hole L, (there being in this Caſe, no end Hole P P) into a Trunk about a Foot ſquare, which conveyed the Air near the ſide of the Ship, through the Gun-Deck and upper Deck, either out, through a Hole cut in the middle of the Gunnel, or up, to its Top.

38. THESE Ventilators were fixed under the Carlings and Legers, which they were unwilling to cut away in a new Ship, till they had been firſt tried and approved of. But it is agreed that it will be better, to cut away the Carlings and Legers, ſo as to make room for the upper Surface of the Ventilators, to be even with and make a Part of the Floor of the Orlop; whereby they will not only take up ſo much the leſs room in the Hold, but can alſo more commodiouſly be come at, in order to repair any Part of them: Here they are placed well out of the way in time of Action.

39. THEY are worked by a Lever twelve Feet long, by two Men ſtanding upon the Orlop. And being each ten Feet long, four Feet three Inches wide, and thirteen Inches deep, throw out at the Rate of a Tun of Air at each ſtroke, ſixty Tuns in a Minute; three thouſand ſix hundred in an Hour; and eighty ſix thouſand four hundred Tuns, in twenty four Hours; which paſſing off thro' a Trunk a Foot ſquare, the Air ruſhes out with a Velocity of twenty five Miles in an Hour.

40. IN this Eſtimate, there is an Allowance made, of two Cubick-Feet and half of Air, to eſcape at each Stroke, between the Edges of the Midriffs and the Sides of the Ventilators.

41. BUT notwithſtanding this great Velocity of the Air here; yet the Motion of it downwards into the Hold, to ſupply what is carried off, is ſo very gentle, that it cannot be perceived; becauſe the Sum of all the open Paſſages for it, through the Gun-Deck, is an hundred and five Feet ſquare; ſo that

the Air deſcends through them an hundred and five times ſlower, than it paſſes off at the Noſe of the Ventilators: And as the Sum of the Openings through the upper Deck, is fifty ſeven ſquare Feet, the Deſcent of the Air through them, muſt be proportionably ſlower; beſides that a further Allowance is to be made, for what Air enters at the Joints of the Port-Holes when ſhut; and through the *Hawſe*, or Cable-Holes at the Head of the Ship.

42. THESE Ventilators may therefore be uſed with great ſafety to the Sick and thoſe who are ſleeping, at ſuch times as the Wind-ſail would, by reaſon of the Strength of the Wind, convey Air with too much Violence. They will alſo be of great Uſe in a Calm, when the Wind-ſail can do little good; alſo when under ſail, at which time the Wind-ſail is not uſed. It is therefore wrong to conclude that theſe Ventilators are uſeleſs, becauſe a Wind-ſail will, with ſome Degrees of Wind, convey much more Air than theſe Ventilators: For it is not the ventilating of a Ship, now and then with a Wind-ſail, when Wind and Weather ſerve,

that will ſuffice; it ought to be done daily, if a due Regard be had to the Health of the Ship's Crew. For ſince it is certain, that nineteen Ounces and a half of Matter perſpires from a Man here in *England* in twelve Hours; this great Quantity of Vapour, together with the Stench that inceſſantly ariſes from the Bilge Water, and from the hot ſtagnant, putrid unwholeſome Air in the Hold, muſt needs make it very adviſeable and deſirable, to be almoſt continually refreſhing ſo bad an Air, either with the Wind-ſail, when that can properly be uſed, or elſe with the Ventilators, which are intended to ſupply the Defects of the Wind-ſail. 'Tis for want of being throughly ſenſible of the vaſt Quantity of rancid noxious Vapours, which are inceſſantly exhaling from a great number of live human Bodies, confined in a cloſe Place, that makes many apt to imagine that it is ſufficient for Health, if ſuch bad Air be ventilated away and exchanged for good Air, at the diſtance of many Days, between each Ventilation: As theſe hurtful Exhalations are too ſubtile to be ſeen floating in the Air, many cannot eaſily be perſuaded that ſuch an Air is unhealthy; notwithſtanding they are ſufficiently warned of it, by the offenſive Smell; which Offenſiveneſs does indeed much abate by Uſe.

43. THERE may be one or more Setts of Ventilators of different Sizes in a Ship, in proportion to the different Burthens of the Ships. And in Hoſpital-Ships, where they cover the Port-Holes with Linnen, which lets the Air in gently, by drawing out the bad Air below, there will be a conſtant gentle Supply of freſh Air.

44. THESE Ventilators will be of great ſervice eſpecially in new Ships, which are obſerved to be the more unhealthy, on account of the greater Quantity of ſappy Wreak which ariſes from new Timber, and makes the confined Air the more unwholeſome.

45. THEY will alſo be an effectual Preſervative of Horſes in Ships, where they are ſometimes ſuffocated, when in a Storm there is a Neceſſity to ſhut the Hatches down.

46. THESE Ventilators will alſo drive out of the Hold of a Ship the dangerous confined Vapour, which ariſes from Corn;

which is ſo very noxious, that ſometimes they dare not venture into the Hold, till after the Hatches have been opened for ſome time.

47. THIS Ventilation will alſo be of ſervice to preſerve not only ſeveral kinds of Goods, but alſo the Timbers and Planks of the Hold itſelf, when laid up in ordinary, as well as when in uſe; and will make the Air in the Hold leſs noxious, tho' it will ſtill be offenſive to the Smell, by reaſon of the Bilge-Water, which is made the leſs offenſive, by often letting in of ſweet Water from the Sea, and then pumping it out; which good Practice ought to be continued, notwithſtanding the Uſe of the Ventilators.

48. AS to the principal Objection, *viz.* the Labour and Difficulty of working theſe Ventilators, how frivolous and groundleſs is it, when the Matter is rightly conſidered; for as they are chiefly wanted, where there is a great Number of Men, ſo the Labour of it equally divided among them, is very inconſiderable; for if two Men can hold to work them for a Quarter of an Hour, four Men, by changing Hands *Spell* and *Spell*, as

they term it, may well work for an Hour. And ſuppoſe there be five Hundred or four Hundred and eighty Men in a Ship, and every one takes his Share of the Work; then once in five Days it will come to every Man's Turn, to work at it for half an Hour. And ſuppoſe there be in a Tranſport, or *Guinea* Slave-Ship, two Hundred Men, as there is often about that Number; then it will come to every Man's Turn to work the Ventilators for half an Hour, once in forty-eight Hours; but here, as the Ventilators will be leſs than the above deſcribed Ventilators, ſo will the Labour of working them be alſo leſs. This, ſuppoſing it neceſſary to do it inceſſantly Night and Day: which need not be in Men of War, when the Port-Holes can be opened, and there is any degree of Wind; which, ſuppoſe it be half the Time of the Crew's being on ſhipboard, then it will come to each Man's Turn but once in ten Days. This Calculation is made on a Suppoſition that every Individual takes his *Trice* at the Ventilator; but let us allow an Abatement of one Fifth for Officers, Sick, *&c.* then will the Work be no more than half an Hour to

each

each Man in eight Days. But ſuppoſe it were to be inceſſant, can half an Hour in five Days be thought ſo hard and great a degree of Labour, as to render the working of the Ventilators an impracticable Thing? Is not the Benefit propoſed thereby, *viz.* the ſaving yearly the Lives of Thouſands, a ſufficient Reward for ſo ſmall a Pittance of Labour? Shall it be ſaid of the brave and undaunted *Britiſh* Sailor; that rather than pull his Hand out of his Boſom, and work for half an Hour, once in ten Days, he will chuſe to lie down and ſuffer that brave manly Spirit to be ſuffocated in a frowzy Stench, a Stench that has deſtroyed the Lives of Millions of the ſtouteſt and braveſt: for the Lamp of Life is ſooner thereby quenched, than many are aware of. One would think it altogether needleſs to uſe many Arguments, to prevail with Men, to make uſe of ſo eaſy and certain a Way, to preſerve their own Lives and that of their Comrades. But I am ſenſible that narrow Minds, who don't care to go out of an old beaten, tho' very bad Track, are apt to view new Propoſals, tho' never ſo rational, only on their worſt ſide, without duely weighing the Conveniencies. This was, within Memory, the Caſe of a very uſeful Contrivance, for ſteering the Rudder by, with great Eaſe and Safety, by means of a Wheel above Deck. And I make no doubt, but that whatever Diſcouragement this may meet with at firſt; yet its great Benefit in preſerving the Health and Lives of Men, will hereafter recommend it to the general Eſteem and Uſe of Mankind: For I cannot think that Men will chuſe to ſicken and die, in and by a Stench, in an old experienced Way, when they have it in their Power to prevent it, by rational and effectual Means. It is well known that all muſt periſh in a Ship, if they will not be at the pains to work the Pumps at proper Times; and ſhould not the ſame Motive of Self-Preſervation induce them chearfully to work the Ventilators, which will not only conduce to the greater degree of Health of all, but will alſo, by God's Bleſſing, be a Means of preſerving the Lives of many? And let it be remembered, that the Labour itſelf will conduce to Health, and be preventive of the Scurvy, a Diſeaſe which Seafaring People are ſubject to.

49. IF a Wind-Sail were effectual for the Purpoſe, why do they ſuffer the Air in Tranſport-Ships, and eſpecially in *Guinea* Slave-Ships, to be ſo intolerably nauſeous? and even in Men of War, it is well known to be very offenſive, eſpecially when the Ports are ſhut. But this Method is here propoſed, in hopes that theſe Inconveniencies might, in a good meaſure, be prevented by having a conſtant gentle Supply of freſh Air, not only now and then, when Wind and Weather would permit, but inceſſantly, or at leaſt often; in the ſame Manner as Animals are ſupplied therewith, whether ſleeping or waking.

50. THESE Ventilators may, not improperly, be called the Lungs of a Ship: And I make no doubt but that they will well deſerve that Name, on account of the great Means of Health they will be to its Vitals the People on board. For ſuch Quantities of freſh Air will greatly contribute to make the Air in the cloſeſt Parts of the Ship more wholeſome, for Sea-Air is Healthy.

(VI.)

51. IT ought in reaſon to convince us of the great Importance that plenty of freſh Air is to our Welfare, when we conſider that the great Author of Nature has allotted near one half of the Trunk of our Body for the Office of Reſpiration, or Breathing only: can any one therefore be ſo unreaſonable, as to grudge the little Space, theſe will take up in a Ship, or the ſmall Labour that they will require, to furniſh great Plenty of freſh Air? Were an Animal to be formed of the Size of a large Ship, we are well aſſured by what we ſee in other Animals, that there would be ample Proviſion made to furniſh that Animal with a conſtant Supply of freſh Air, by means of large Lungs, which are formed to inſpire and breathe out Air in the ſame manner as theſe Ventilators do. Can it therefore be an unreaſonable or an improbable Propoſal, to attempt to furniſh Ships, Goals, Hoſpitals, *&c.* in the ſame manner with the wholeſome Breath of Life, in exchange for the noxious Air of confined Places, which

is rendered unwholeſome, by the great Quantity of rancid Vapours, which are inceſſantly exhaling from human Bodies; and are the Occaſion of much Sickneſs, and of the Death of Multitudes?

52. IT is well known that Infections are principally drawn in by the Breath; thus the Fumes of fermenting Wine, Beer or Vinegar, which inſtantly kill any Animal that comes within the Reach of them, produce their pernicious Effects by being drawn into the Lungs. Which is further confirmed by the following Experiment made by Dr. *Langriſh* of *Petersfield* in *Hampſhire*, *viz.* He cut open the Wind-Pipe of a live Dog, and ſtopped the upper Part of the Wind-Pipe towards the Mouth with a Cork; the Dog breathing freely thro' the other Part. Then the Dog's Head being put into a round Hole cut in the End of a large Box, with a Collar of Leather which was nailed round the Hole and tyed round his Neck, to prevent the Fumes of burning Brimſtone from coming out to offend his Breath: Things being thus prepared, the Dog received no Harm as to his Life; notwithſtanding

ſtanding the Fumigation was ſo ſtrong, and continued ſo long, as to put out his Eyes.

53. THE Conſideration of the great Quantity of rancid Vapours that inceſſantly exhales from human Bodies, eſpecially where there are a Multitude confined in a ſmall Compaſs, fully evinces the Inſufficiency of any Attempts to make the Air in Ships wholeſome, by only a few Hours Ventilation in every twenty-four Hours; it were to be wiſhed that there ſhould not be ſo much as one Hour without Ventilation when the Ports are ſhut; but when the Dews fall in greateſt quantity, it may perhaps be adviſeable to ceaſe conveying the external Air into a Ship, for about an Hour at that Time. Dews do not always fall in greateſt plenty ſoon after Sun-ſet, but in ſome Climates ſome Hours after, as I am informed, *viz.* ſooner or later in proportion to the different Heights to which the Vapours are raiſed by the Heat of the Sun. The Ventilation muſt therefore be regulated as Experience ſhall ſhow to be beſt, in different Circumſtances of the outward Air, as to its Temperature of Heat or Coldneſs, Moi-

ſo ſurcharged with them: but yet this Eſtimate ſhows, how very great the Stench of ſuch an Air muſt neceſſarily be; which not only retards Reſpiration, but alſo Perſpiration, which is very prejudicial. Dr. *Hoadley*, in his ingenious *Lectures on Reſpiration*, obſerves, " That the Air itſelf has ſo " great a ſhare in the Action of Reſpiration, " and is ſo neceſſary likewiſe to the Health " and Vigour of the Body, that no remark- " able Alteration can be in it, without our " being very ſenſibly affected by it.—Con- " ſequently, when the Air we breathe is " loaded with Vapours, which either ren- " der it too warm, or deſtroy its Elaſticity, " or both, it becomes unfit for Reſpiration, " and interferes with the Action of breath- " ing."—And he further obſerves, " that " unleſs the Chyle, which is mixed with the " Blood, be brought to the Lungs in pro- " per Quantities, and endowed with proper " Qualities; unleſs the Diſcharges thro' the " Sides of the Veſicles of the Lungs be re- " gularly and duely performed; unleſs a " proper Quantity of Air-Particles be ab- " ſorbed, to ſupply the active Principles, " ſo neceſſary to the Warmth of the Blood,

" and the Coheſion of its Parts; it muſt by " degrees grow leſs and leſs fit for the Pur-" poſes of Life: So that by degrees the " Blood will be ſo impaired and broken, " that when it moſt wants the Aſſiſtance of " the Lungs, it will be brought thither, " when it is only fit to choak up and clog " the Veſicles, and capillary Arteries, ſo " as to prevent the receiving the ſervice it " could receive in paſſing through the " Lungs."—— Hence, 'tis no wonder that when we breathe an Air, thus loaded with Vapours, it ſhould be apt to cauſe, what are called Goal-Diſtempers; which Inconvenience might in a great meaſure be prevented, if ſuch cloſe Places were ventilated with freſh Air; for want of which, many unhappy Perſons are not only deprived of Liberty, in Goals, but too often even of Life alſo.

56. IT has long been found of ſome Benefit towards the purifying the Air in Ships, to waſh and ſprinkle them with Vinegar between Decks. I wrote the following Propoſal to Dr. *Martin*, Phyſician to the late *Lord Cathcart*, about two Months before they ſailed from *Spithead* in the Year 1740; *viz.*

viz. to dip many Cloths in Vinegar, and hang them up in all proper Vacancies between Decks, whereby great Quantities of Vinegar would intermix and float in the Air. For I had found by Experiment CXVI. Vol. I. p. 266. of my *Statical Eſſays*, that an Air, which paſſed through Cloths dipped in Vinegar, could be breathed to and fro as long again, as the like Quantity of Air, which was not impregnated with Vinegar: ſo that Vinegar uſed in ſuch plenty between Decks, might a little refreſh the Air; yet where the Stench is great, it can be but of little Benefit, and that only for a ſhort time.

57. VINEGAR has been long looked upon as Antipeſtilential, whence it is probable, that there may be a Ferment, between this Acid, and the too alkaline rancid Air, which may thereby be reduced, in ſome degree, from its alkaline, to a neutral, more wholeſome ſtate; for many alkaline and acid Mixtures produce Neutrals. It ſeems therefore probable, that if Cloths dipped thus in Vinegar were hung up in the Chambers of ſome ſick Perſons, it might be of ſervice to the Sick. But tho' Vinegar may be of ſome

Benefit in curing in ſome degree the ill Quality of ſuch cloſe rancid Air in Ships; yet it will ſtill be ſurcharged with Vapours, which will very much incommode and diſorder our breathing.

58. For, as Dr. *Hoadley* obſerves, "Reſpiration is beſt carried on, when the Air "we breathe is perfectly claſtick, and cooler "than the Vapours in the Lungs; in which "ſtate the warm Vapours in the lower parts "of the Lungs, aſcend up through the cooler, "purer, freſh inſpired Air: the oftner there"fore we breathe the ſame Air to and fro, "it will not only be more and more loaden "with Vapours which, we find by Expe"rience, deſtroy its Elaſticity; but it will "alſo come nearer and nearer to the ſame "degree of Warmth with the Air in the "Lungs, and conſequently will loſe more "and more of thoſe Properties, Coolneſs "and Elaſticity, upon which the Circula"tion of the Air in the Lungs depends, and "by which the Air is perpetually changing "in ordinary Reſpiration. There muſt "therefore, in a cloſe Air, be a Time after "which the Air in the veſicular Cavities of

" the Lungs can be no more exchanged " for the Air that is new drawn into the " Lungs; they being both, near equally hot, " and equally loaden with Vapours." So that nothing but a thorough ventilating Air can be an effectual Cure.

59. And for the ſame Reaſons, hot cloſe Rooms in private Houſes, which many are too fond of, are not ſo agreeable to breathe in, nor ſo wholeſome, as Rooms that have a due Proportion of freſh Air admitted into them; beſide, ſuch warm cloſe Air tends much to relax the Body. It is the Advice of *Celſus*, an eminent Phyſician, to have large Rooms for thoſe that are ſick of a Fever, or elſe to have a ſmall Fire in the Chimney, thereby to draw off the bad Air.

60. I Have obſerved the Air to be very diſagreeable in the Churches of ſome populous Pariſhes, in which there are frequent numerous Congregations. Now the Air in ſuch Churches might eaſily be made freſher and more agreeable, if in the upper part of the outward Doors a free Entrance were made for the Air, through branched flouriſhed

Iron-work, inſtead of cloſe Pannels: Then by ſetting open the inward Skreen-Doors, when there is no Congregation, the outward Air would have a free Admittance, without the Inconveniencies that would ariſe from leaving Windows open in all Weathers: And by the ſame Means the great Dampneſs, which is in ſome Country Churches, might be prevented.

61. I HAVE been the more particular in explaining the Manner, how ſuch bad Airs produce their pernicious Effects, to evince of how great importance it is, for us to uſe our beſt endeavours to avoid them. And I make no doubt but when due trial ſhall have been made, that theſe Ventilators, or Lungs, will be found ſo uſeful in Ships, that effectual Care will be taken to find room for them; and that they will not be looked on as cumberſome, but very valuable Furniture, which will ſupply them with freſh Air, in ſuch proportion as ſhall be found moſt commodious; they being moſt ſimple and conform to Nature's own Method of working.

62. AND as to *Goals* and *Work-Houſes*, when they have full leiſure, the Exerciſe and Benefit of freſh Air to refreſh and cheer them, will, I doubt not, induce them cheerfully to work theſe artificial Lungs.

63. BUT in *Hoſpitals*, where alſo freſh Air would be of great Importance, they muſt be uſed with Caution ſo as not to incommode the Sick.

64. BUT whatever Method is uſed to ventilate Ships, Goals, Hoſpitals or Work-Houſes with freſh Air, in order to make it more effectual, it is abſolutely neceſſary to uſe all Methods of Cleanlineſs by frequent waſhings, *&c.* And notwithſtanding all theſe Means, there muſt needs be ſome degree of Frowzineſs, where many Perſons are incloſed in a ſmall compaſs: but it will be much the more healthy, on account of freſh Air and Cleanlineſs.

(VII.)

65. THE thus ventilating of Ships will be a probable Means, to pre-

vent, in a great meaſure, thoſe infectious peſtilential Diſtempers, which are too often occaſioned by the bad Air in Ships, as alſo in Goals. When this happens, a very likely Means to cure Ships of the Infection would be to fume them well with burning Brimſtone, ſhutting all the Port-Holes, and covering with Tarpaulins all the Hatchways, Gang-ways and Gratings of the upper Deck. And this may be done with great Safety to the Ship, by placing, according to the ſize of the Ship, one or more metalline Pots on the Ballaſt in the Hold, each of them having ſome Wood-Aſhes or Sand, and four or five Pounds of Brimſtone, fired by a hot Iron Bullet; taking care that no combuſtible Matter be within two Yards of the burning Brimſtone, either above or ſide-ways. Any one that is doubtful may ſoon be ſatisfied, that there will be no Danger of firing the Ship by this means, if they pleaſe to try the thing firſt at Land, to ſee how far the Scorch of ſuch a Quantity of burning Brimſtone reaches. I need not caution that every Perſon muſt be above Deck while this is doing, for the burning Fumes will mount with great Velocity and

Acrimony up between Decks, and will deſtroy all living Creatures there, as Rats, Bugs, and other Inſects. When the Fumigation has been over for ſome time, the Coverings muſt be taken off the Hatch-ways, *&c.* and the Port-Holes opened, to air the Ship; for which Reaſon it will be beſt to do this, not in a Calm, but when there is ſome degree of Wind.

66. Mr. *Holland*, the Maſter Ship-Wright of *Woolwich*, informed me, that he was once concerned in fuming a very infectious Ship, in which many hundreds had died in a ſhort time, with eight Buckets of Tar at once, which gave a ſtrong Fume, with hot Logger-heads, that is, large Bullets with long Iron Handles to them. But as the Fumes of burning Brimſtone are much more acid than thoſe of Tar, ſo they are more likely to cure peſtilential Infections, which are with good Reaſon thought by Phyſicians to be highly alkaline.

67. I HAVE known ſeveral Inſtances, where after Perſons have well recovered from the Small Pox, the Houſes have been

fumed, the Feather-Beds being firſt lain hollow, on Chairs turned down: And ſome of the Blankets being nailed before the Chimneys, to prevent the Fumes eſcaping, and the reſt of them being nailed unfolded againſt the Walls, and all Drawers and Boxes ſet open: Then four or more Pounds of Brimſtone being laid on Wood-Aſhes, (which give no ill ſcent) in an Iron Pot or Pots, according to the ſize of the Houſe; and placed on ſome Sand or Earth in the midſt of the loweſt Floor: the Brimſtone was fired by a hot Bullet, or other large piece of Iron laid on it. After the Houſes were thus fumed, thoſe Perſons who left the Houſes, for fear of Infection, have with ſafety returned.

68. THE acid Fumes or Spirit of burning Brimſtone, ſeem therefore effectually to ſtop the malignant Ferment of the infectious Matter, that was in the Furniture, Walls, *&c.* of the Houſes, which by a Ventilation of freſh Air would require a long time to cure.

69. BUT the Remains of this Fumigation will not be ſo offenſive afterwards, if

the Houſe be fumed by means of a large Iron Pipe, or Tube of five or ſix Inches Diameter; which ſtanding without doors on a proper Stove, with Brimſtone and Charcoal burning together; the Fumes are conveyed up the Tube in at a Window; in which way ſeveral Houſes in *London* and the Country have been fumed for Bugs; neither is there in this Method the leaſt Danger of firing a Houſe.

70. AND as the Infection of the Plague is alkaline, it is probable, it might be of ſervice, if a Ship with infected Goods were firſt fumed with burning Brimſtone: And then when the Bale or other Goods were taken out of the Ship, to have them unfolded in a large Ware-houſe, where they could be hung up unfolded to their full length; the Ware-houſe being all the time fumed inceſſantly with burning Brimſtone, to ſuch a degree as the Men employed could well bear: Theſe Fumes might probably prevent the ill effects of the Infection which lay in the Holds, and which could not be come at when the Goods were fumed in the Ship. And when the Ware-houſe was full of the

hung up Goods, then it would be adviſable to give them a much ſtronger Fumigation, the more effectually to cure the Infection. This is what is done, as I am informed, by Men who have performed a Quarantine, they being then lain with their Mouths downwards in a Room, and then fumed with Brimſtone.

71. It were eaſy to deſtroy Vermin when they infeſt a Neighbourhood, ſuch as Badgers, *&c.* by providing a good Quantity of Tow dipped in melted Brimſtone, which being faſtened by a *With* to a long Pole, wherewith to convey it, when fired, as far as may be into the Badger's Hole; the Mouth of the Hole or Holes being immediately cloſed up; this will probably ſmother any living Creature there.

A
DESCRIPTION
OF THE
Small Ventilators,
And their Uses.

(VIII.)

72. AS I was ſtanding in the *Captain*, with Sir *Jacob Ackworth* the Surveyor of the Navy, on the Gun-Deck over the Bread-Room; conſidering how to ventilate the Bread-Room with freſh Air; there happening to ſtand by me a Carpenter's Cheſt with Tools, it occurred to me, that it might be done by a ſmall moveable Ventilator about the ſize of

that Cheſt. And accordingly I made a Ventilator at home of the following Size and Figure, *viz.* Its Length from C to E, *Fig.* 6. was four Feet, its Breadth A C ſixteen Inches, its Depth A F thirteen Inches, all in the Clear within. The Midriff was fixed in the ſame manner with thoſe in the larger ones, was moved up and down by the wooden Handle M fixed in a ſquare Hole, to the top of the Iron Rod R Z; which Rod had a Rivet-Joint at its lower end near the Midriff.

73. IT is beſt to ſcribe the end A F of the Ventilator circularly, with the Midriff it ſelf, when fixed in its Place with Hinges, becauſe then it will deſcribe the true Curve-Line that it moves in; which will otherwiſe not be ſo true, as I have found by Experience, becauſe the poſition of the Hinges prevents its ſcribing a true circular Curve.

74. THE Holes of the Valves 1. 2. at which the Air enters, were four Inches ſquare; the Valves themſelves were five Inches; which will make little Noiſe when double lifted, as the Valves of the great Ventilators were. The Air ruſhed out at two

other like Valves, into the Noſe B X thro' the Hole X. There was a like Hole at the Bottom of this Noſe, which was a Foot long, and another at the Side: which three Holes had all Sliders to them, to open or ſhut either of them at pleaſure. Tho' the Midriff is worked up and down with Eaſe, yet it is beſt for two to change Hands often, which will make it very eaſy to them.

75. THE Midriff riſing and falling a Foot, will convey at each Stroke two Cubick Feet of Air; two Thirds of a Cubick Foot being allowed for what Air eſcapes at each Stroke, between the Sides of the Ventilator, and the Edges of the Midriff: The Midriff was planed rounding on all its Edges, to prevent its pinching any where. At the Rate therefore of an Hundred and Forty Strokes in a Minute, which may be done with Eaſe, this Ventilator will convey four Hundred and twenty Tuns of Air in an Hour: And may therefore be very uſeful in preſerving the Bread in the Bread-Room ſweet and dry.

76. For which Purpoſe, a Pair of them were made to be uſed in the *Captain*; which being placed on the Gun-Deck, over the fore Part of the Bread-Room, Air was conveyed thence, by a ſquare wooden Trunk, which paſſed through a Hole cut in the Deck, down within a Foot of the Bottom of the Bread-Room; and the Air aſcended, thro' the After-Skuttle of the Bread-Room. And in order to try the Efficacy of this Inſtrument, in the Preſence of the Maſter Ship-Wrights, and other Officers of *Woolwich* and *Deptford* Yards, who were then ſummoned to paſs their Judgment on the Ventilators; the Bread-Room was filled with the Fumes of ſmoaking Tar, which was in a great meaſure blown out by theſe Ventilators, in three Quarters of an Hour's working them; and in an Hour's blowing, the Room was quite cleared of the Fumes.

77. And in the ſame Manner, the Bread may be kept perfectly dry and ſweet, by blowing in freſh Air now and then, as Experience ſhall ſhow needful, for an Hour in

the midſt of dry Days, when the Port-Holes can be opened, ſo as to have freſh Air between Decks; otherwiſe it were better, to have the Air conveyed by a Trunk reaching from the Noſe of the Ventilators to the neareſt Port-Hole, in order to prevent the driving in among the Bread the offenſive Fumes, which are between Decks, eſpecially when the Ports are ſhut: Theſe Fumes being, as I am informed, hurtful to the Bread, it being obſerved that the Bread does not keep ſo well, in Ships where there are many Men, as where there are few.

78. AND whereas the Peaſe and whole Oatmeal are apt to heat and ſpoil in Casks, eſpecially in hot Climates, this Inconvenience may eaſily be prevented, by putting them into a large Bin, with a falſe Bottom of Hair-Cloth laid on Bars, ſuch as are deſcribed in Numb. 103, 104. *Fig.* 8. whereby freſh Air may be blown upwards through them, at proper Times with the ſmall Ventilators, in the ſame Manner as through the Bread.

(IX.)

(IX.)

79. BY this means, both the Bread, Peaſe and whole Oatmeal, may be kept very dry, ſound and ſweet; and if muſty, may thus be ſweetened. But then his will not deſtroy the Wevels, Maggots, and Ants, which abound, eſpecially in hot Climates, and devour much. The moſt commodious Method that occurs to me for deſtroying theſe Animals, would be by driving the Fumes of burning Brimſtone, both into the Bread-Room, and upwards thro' the Peaſe, by means of the ſmall Ventilators, which may be done in the following manner, *viz.* by fixing a Trunk five Inches ſquare within, to the Holes in the Noſe of the Ventilators, at which they draw in Air; which Trunk ſhould reach to three or four Feet, without and beyond a *Lee* Port-Hole. Under the End of the Trunk on the outſide of the Ship, ſhould be fixed a ſquare wooden Hopper or Tunnel, with its wide Part downwards, which is to be near two Feet ſquare: This Tunnel, and a good Part of the Trunk to be lined within ſide with Tin,

Iron Hoops. A very little Ventilation will be ſufficient to preſerve the Corn. It will be needful to have Partitions in the Bin, to prevent the ſhifting of the Corn, on the heeling of the Ship. And at each Partition there may be a Sliding-Board, five or ſix Inches broad, ſet Edgewiſe; that when any part of the Bin is empty, by puſhing down that Slider, the Air may be prevented from going in waſte to the empty Part. Or if all Parts of the Bin be from time to time equally emptied of Corn, then there will be no occaſion for the Sliders. The Air-Trunk leading down from the Ventilators, may enter at the Middle of the Bin, either in Front or behind. I am credibly informed, that Sugars were formerly ſtowed in Bins in Ships, before our Sugar-Plantations had Pipe-Staves from *New-England.*

82. THESE ſmall Ventilators will alſo be of uſe to keep the Powder in the Powder-Room dry; for a ſtagnant Air, eſpecially when damp, is well known to damage Powder: And ſome degree of Dampneſs, notwithſtanding the utmoſt Precaution, will ariſe, if there were no other Cauſe, even

from the ſappy Vapour of the Wood of which the Room is made, eſpecially in new Ships.

83. THEY will alſo be of excellent uſe, to purify moſt eaſily, and effectually, the bad Air of a Ship's Well, when there is Occaſion to go down into it, by blowing Air through a Trunk, reaching within a Yard of the Bottom of the Well, both for ſometime before, and during their ſtay there: This will be a much eaſier and more effectual Way, than the preſent Method of letting in Water and pumping it up: yet ſeveral are frequently ſuffocated there, notwithſtanding this Method; for as the Eye cannot diſcern a ſuffocating from an unſuffocating Air, ſo many ruſh into inſtantaneous Death, thinking there is no Danger where they ſee none. Now driving out all the bad Air by good Air, will be an effectual Remedy; but however, for greater Security, it will be adviſeable to let down a lighted Candle firſt, for that Air is always dangerous to animal Life, which will extinguiſh a Candle.

(X.)

84. BEFORE I thought of this ſafe and eaſy Method of doing it, I had propoſed to make uſe of the following Inſtrument, *viz. Fig.* 7. X. Z. a Piece of light Alder or Willow, a Foot long from X to Z, and two Inches and a half thick, both in Breadth and Depth, with a Hole K, L, Q, U, five Eighths of an Inch in Diameter, bored thro' it; and at C B ſhort Foſſets with like Holes bored through them; to which Foſſets, hollow Reed-Canes are to be fixed, by means of ſhort ſupple Leathern Pipes, ſo that they are flexible at theſe Joints. O, N, and T S, are ſquare Holes two Inches deep, and an Inch and three Quarters wide, with their ſole Leather Covers F G, and H, I nailed over them. I, N is a broad Leathern Valve moving on Joints at I, ſo as to open by the Force of the Air which paſſes down the Pipe B, K, L, when Breath is drawn in by the Mouth at the Foſſet E, which ſtands five Eighths of an Inch above G, H. G, S is another like Valve, which ſhuts the Hole at Q cloſe, while the Breath

is drawing in at E; but when, on the contrary, the Perſon breathes out at E, then the Valve I, N cloſes the Hole L; and the other Valve G, S opens for the Breath to paſs freely off through the Pipe V, A, by which means, the Perſon always draws in freſh Air. At O and T are two ſtiff Wires fixed, to prevent the Valves opening ſo far, that the Force of the Breath, which is but ſmall, could not ſhut them; to do which, it is adviſeable to breathe with ſome little Force. This Inſtrument is to be fixed to the Mouth by a Tape or Cord tied round the Head; and it will be convenient to have Cuſhions at the Corners C and D, for the Cheeks to bear off a part of the Preſſure of the Ligature from the Mouth.

85. I BREATHED thro' this *Reſpirator* for a Quarter of an Hour, with great Eaſe, when the Reed-Canes fixed to it, were four and a half Feet long. By means of this Inſtrument, a Man might go with great Safety into the moſt noxious Air of a Ship's Well, his Noſe being ſtopped with Cotton or Linnen. But I found on propoſing the Thing, that the Sailors would rather run the Ha-

zard of Suffocation than make uſe of it: However, as this Inſtrument may be of uſe in ſome noxious Trades, and other Caſes where it may be requiſite to go into a ſuffocating Air, I have here given a Deſcription of it.

86. THIS Inſtrument might perhaps be of uſe, if there were four or five Feet depth of Water in a Ship; for by the Help of it, a Man might continue under Water that Depth, for a conſiderable Time, to rectify any thing amiſs at the Bottom of the Well, or to ſtop a Leak that could be come at in the Hold.

87. I KNOW not to what Depth under Water a Man can breathe with this *Reſpirator*; 'tis to be feared but a ſmall Depth, becauſe the Weight of Water on his Belly will preſs ſo hard on his Midriff, as to hinder his drawing in Breath: unleſs it ſhall be found on trial, that he can fetch ſhort Breaths, by the Dilatation and Contraction of the riſing and falling Ribs; but then, that muſt be with a ſufficient Force to ſhut the Valves. If a Man could thus breathe at ſix

or eight Feet under Water, then if a ſmall leaky Ship were put ſo far on the Careen, as to have its Keel but ſix or eight Feet under the Surface of the Water, a Man might, by means of this *Reſpirator*, go down to the Keel, by an under-girding Rope, and there ſearch for and ſtop Leakages. But if on trial it ſhall be found, that a Man cannot thus go deep enough; yet he might perhaps go deep enough for Ships, in ſome degree on the Careen, by means of a Copper Coat of Mail to cover the Trunk of his Body up to the Arm-Pits, that the Arms may be at liberty: by thus keeping the Preſſure of the Water from the Belly, it has been found to do at twelve or fifteen Feet Depth. Theſe Things I mention, hoping, that at leaſt they may be Hints, for farther Improvements in ſo very important a Caſe, as well deſerves the moſt diligent Reſearches.

(XI.)

88. THERE is another Uſe may be made of theſe ſmall Ventilators at Sea, *viz.* to ſweeten ſtinking Water; and that they will be uſeful to that Pur-

poſe, is evident from the following Trials, *viz. April* the 21ſt, a temperate dampiſh Air, with a weſterly Wind, I took near a Pint of hard Well-Water, which had ſtood in a Quart Bottle till it ſtank, in order by its Putrefaction to diſſolve the tartarine Sediment of Port Wine, which it effectually does. And muſty Casks, as I am informed, may thus be cured, by keeping them for ſome time full of ſtinking Water; for Putrefaction is a moſt ſubtile Diſſolvent. This ſtinking Water I put into an earthen Baſon, and placed it at ten Inches diſtance under the Noſe of the Ventilators. After a Quarter of an Hour's blowing on the Water, its Stink was conſiderably abated, ſo as to be very ſenſibly leſs than that of the remaining Water in the Bottle. And being examined after every Quarter of an Hour's Ventilation, its offenſive Smell and Taſte was leſs and leſs, ſo as in an Hour and half's Ventilation, it had no ſenſible ill Smell. Yet it had not the agreeable Flavour of freſh Water, which might in ſome meaſure be owing to the Tartar of the Wine; for it is commonly obſerved, that ſtinking Water, in Wine, Beer or Cyder Veſſels, never becomes perfectly ſweet and well taſted, tho' in Water Veſſels, ſome ſtinking Waters will become very ſweet; which is obſerved of *Thames* Water taken up near *London*, and of other Waters that have ſome foul Mixture in them; their Impurity, after the putrid Ferment is over, falling to the Bottom, there attract to them all Impurities out of the Water, whereby it becomes fine and clear. And this is the common known Caſe of Water in Ciſterns, which is found to be the finer and clearer for having ſome Filth at the Bottom of their Ciſterns; which Water is often found to become the fouler and thicker, for having the Filth at the Bottom taken away. 'Tis for the ſame Reaſon, that ſome put Gravel with a little Salt into Ciſterns or Veſſels of foul Water, in order to make it clear.

89. MAY 19th, a warm Sun-ſhine and dry Air, having thirty-four Days before, filled a clean Cyder Hogſhead with *Thames* Water, taken up above the Tide, it then ſtank very much. The greateſt Part of this ſtinking Water was put in equal Portions into two open Veſſels, where it was ex-

poſed to the Air, with a Surface of two Feet and a half in Diameter; being eight Inches deep.

90. Its ſtinking was manifeſtly abated, after an Hour's Ventilation; I ſtirred it often during the firſt Hour, but deſiſted, on obſerving by floating Things in the Water, that there was a continual Circulation of the Water, it being by the Force of the Air depreſſed in the Middle, and raiſed near the Sides of the Veſſel; the higher Water at the Sides conſtantly deſcended, and roſe towards the Middle, as was evident by the Courſe of the floating Things in it. And it is the ſame with the Waters in Rivers, whoſe Surface having an inclining Plane, the upper Parts are continually deſcending, which is the Cauſe of Rivers freezing at Bottom firſt, which Ponds do not do, their Water having no ſuch deſcending Motion; but the cold Surface-Water of Rivers, continually deſcending, it freezes ſooner at the Bottom than on the Surface, notwithſtanding the Surface Water is colder than at the Bottom: the Reaſon of which is, that the Bottom Water has leſs Motion

than the Surface Water; for where the Bottom Water has a brisk Motion, it will not freeze at the Bottom.

91. It is this deſcending, and as it were inteſtine Motion of River Water, that contributes to the preſerving of it ſweet, as well as the progreſſive Motion of Rivers: And in the ſame, the Upper and Nether Sea-Waters are blended together, by the very unequal Preſſure of its Surface, when it is formed into vaſt Waves and Surges, which contributes to the keeping its lower Waters ſweet, which are too deep to be otherwiſe affected by the Agitation of Storms.

92. After the ſecond Hour's Ventilation, the Smell of the Water was more ſenſibly abated.

93. After the fourth Hour it was ſweetened, as much as ſix Spoons-full of the ſame Water was, by ſtanding expoſed to the Air, for twenty-four Hours.

94. After ſix Hours Ventilation, it was much the ſame as the above-mentioned

Pint of Water was, with an Hour and half's Ventilation; for this Water being in a Cyder Cask, wanted the agreeable Taſte of freſh Water: it is probable therefore, that the ſtinking Water of Water-Casks, will be better taſted than this, when thus ventilated.

95. THE putrid ſulphureous Particles of ſtinking Water, ſeem to be the moſt volatile; for when, in my Reſearches to make Sea-Water wholeſome, I diſtilled ſome that was very putrid; that part of it which was diſtilled into the Receiver, did ſtink intolerably; but what remained undiſtilled, was not very offenſive. No wonder then, that freſh Air, which is electrical, and ſtrongly attracts Sulphur, ſhould in thus ventilating ſtinking Water, carry off the more ſubtile volatile ſulphureous Particles, which cauſe the moſt offenſive Smell, and which are ſometimes apt to flaſh into a Blaze, when Water-Casks are firſt opened.

96. I HAVE here mentioned the Event of theſe two Attempts to ſweeten ſtinking Water thus, not with expectation they will

be at the trouble to ſweeten great Quantities of Water to this degree in Ships; but to ſhew that the highly offenſive Degree of ſtinking Water, may be greatly abated, with an Hour or two's Ventilation: perhaps very long Ventilation might not perfectly ſweeten ſome Waters. For tho' *Thames* Water will turn ſweet after ſtinking, yet pure Spring-Water is not obſerved to turn ſweet ſo ſoon. By opening the Bung-Hole, Water ſweetens in ſome degree in twenty-four Hours, as did the other half of the Hogſhead of Water, after having ſo large a Surface expoſed to the Air for twenty four Hours; but yet it ſtank more than the Water in the other Veſſel did, after but one Hour's Ventilation.

97. If any ſhall think fit to try it, it may be done without any other additional Cumber to a Ship, than a wooden Trunk, five Inches ſquare within, to reach from the ſmall Ventilators, down to the ſweetening Water-Cask; which having its Bung-Hole ſtopped, may have ſquare Holes cut at each end of the Bung-Stave, wherein to fix the Ventilator Trunk at one End, and a like

ſhort Trunk at the other end, to prevent the Water's running over, by the heeling of the Ship; by this means, an inceſſant briſk Stream of Air may paſs over the Surface of the Water, from one end of the Caſk to the other. Care ſhould be taken to fill the Caſk only ſo full, as to leave a ſufficient Breadth of Surface of Water, for the Air to act on the Water.

98. These are the ſeveral Offices of the ſmall Ventilators, which a Wind-ſail cannot well perform.

99. They may alſo be of uſe to drive out the bad Air of Vinegar Tuns, and other large brewing Veſſels, when Men want to go in with ſafety to clean them.

(XII.)

100. I Cannot diſmiſs this Subject, without ſaying ſomething in behalf of thoſe, who cannot ſpeak for themſelves: I mean young tender Infants; who are often ſwathed up in ſuch a manner, as muſt needs greatly incommode their Breathing, and

conſequently be often very hurtful to them. For when their tender Bodies are cloſe confined in Swathings, neither their Breaſt nor Belly can riſe ſo freely, as they ought to do, when the Child draws in its Breath: And conſequently, not only its Breathing, but Digeſtion alſo are thereby greatly incommoded; for the Digeſtion is much promoted, by the Kneadings of the Midriff on the Stomach, which are no leſs than twelve hundred in an Hour: And in Proportion as the Degree and Force of theſe numerous Kneadings are abated by Swathings, ſo will the Digeſtion be accordingly retarded and incommoded; the ill Conſequences of which, to the poor Child's Health, few Nurſes are aware of. Thoſe of them who will not be perſuaded to leave off that old very bad Practice, ought themſelves to be well ſwathed up, to be made duly ſenſible of the Miſery they would ſuffer thereby in one Night.

101. THERE is another very bad Practice in relation to Infants, the ill Conſequences of which, few Nurſes ſeem to be aware of, *viz.* It is well known that for very important Reaſons, the Skulls of new-born

Children are not in all Parts turned to Bone. But ignorant Nurſes taking the ſoft Part of the Skull for a great Defect in Nature, are apt, too often, to attempt to cloſe the Mold of the Head, as they call it: that is, to compreſs together, by ſtroking and Bandage, thoſe Parts of the Skull which are bony, expecting thereby to unite thoſe diſtant bony Parts together; not knowing that the intermediate ſoft Parts will turn to Bone; and little thinking what Injury they do thereby to the tender Infants, by thus compreſſing their Brains, and thereby cauſing convulſive Fits, and perhaps ſometimes a great Tendency to Head-Aches during their whole Lives, *&c.* Whereas, if they would but let Nature alone to do her own Work, the Head would have its natural Shape, and the whole Skull would of itſelf turn to Bone: And this without Compreſſing the Brain, which is often attended with ill Conſequences.

AN

ACCOUNT

OF THE

USEFULNESS

OF

VENTILATORS

IN

Preſerving all Kinds of GRAIN
Sweet, and Free from WEEVELS
and other Inſects:

Alſo, in Drying MALT, HOPS, GUN-
POWDER, *&c.*

THE USEFULNESS OF VENTILATORS,

In preſerving all Kinds of GRAIN Sweet, and free from Weevels, &c.

(XIII.)

102. AS Experiments often give Hints for new Experiments, and farther uſeful Diſcoveries, ſo the attempting to convey great Quantities of Air, by means of the above-deſcribed large Ventilators, has led to a Diſcovery, which will be of great ſervice to the World, in preſerving Corn in Graineries, and Ships, ſweet and dry, and free from being eaten

by Weevels or other Inſects; by which vaſt Quantities of Corn are yearly ſpoiled and deſtroyed all over the World: I am credibly informed by a *Spaniſh* Merchant, that not leſs than 80,000 Pounds worth of Corn was ſpoiled in exporting in one Year, about eight or nine Years ago.

103. Now it is moſt eaſy to preſerve Corn, by blowing freſh Air upwards thro' it: In order to which, wooden Bars, or large Laths, muſt be nailed on the Floor of the Grainery, about an Inch diſtance from each other, if only a Hair-Cloth be laid on them: But coarſe Wire-Work is, in ſome Malt-Kilns, laid under the Hair-Cloth, or Basket-Work made of Oſier might be uſed, and then the Bars may be two or three Inches diſtant; and there may be the ſame Diſtance, if an Iron-Plate full of Holes be laid on them, as is done in many Malt-Kilns. Theſe Laths B B, *Fig*. 8. may be laid acroſs other Laths, A Z. A Z. A Z. nailed fifteen Inches diſtant, and two Inches or more deep, that there may be a free Paſſage for the Air under the Laths.

104. THE Under-Laths muſt come about ſix Inches ſhort of the Wall of the Grainery at one end of them: on which end a Board Z Z, *Fig.* 8. is to be ſet edgewiſe, yet ſloping againſt the Wall X X, whereby a large Main Air-Pipe Y is formed; which having an open Communication with all the Interſtices between and under the Bars, when Air is blown forcibly, and in great Quantities, through the Hole M N, into this large Air-Pipe or Trunk, it muſt neceſſarily be driven up, from between the Laths, through the whole Corn in the Grainery, and will conſequently carry off with it, the moiſt Exhalations of the Corn; which when confined in it for ſome time, will, as it is well known, ſpoil it. By this means therefore Corn may eaſily be kept for many Years dry and ſound, and much better conditioned, than in cloſe vaulted ſubterraneous Graneries, as is done in ſome Countries.

105. THAT I might be aſſured that Air could in this manner be conveyed up thro' great Depths of Corn, I took a wooden Tube or Trunk, which was five Feet four Inches long, and near three Inches ſquare within ſide;

and having nailed a piece of thin Copper-Plate, full of ſmall Holes at the Bottom of it, I filled it full of Wheat; then having fixed to the Bottom of the Trunk, by means of a ſhort piece of leathern Pipe, lined with a Bladder, the Noſe of the Kitchen Bellows; on blowing at a common moderate rate, the Air paſſed up through that depth of Wheat, with a Force ſufficient to raiſe Paper and to blow off Leaf-Tinſel. I repeated the ſame Experiment in another like wooden Trunk, which was nine and a half Feet long, where the Air, in aſcending up through the Corn, raiſed the Tinſel alſo, though not ſo forcibly as in the ſhorter Trunk, becauſe it met with more Reſiſtance, in paſſing through a greater depth of Corn; which therefore required proportionably larger Bellows, and a greater Force: for theſe Bellows contained but ſeven Half-Pints of uncompreſſed Air; as I found by blowing the whole Air which they contained, through a leaden Siphon fixed to the Noſe, up into an inverted Glaſs Receiver full of Water.

106. IN order to find the Quantity of Space there is between the Grains of Wheat,

for Air to paſs through, I poiſed a Quart Pot in a pair of Scales; then filling it full of Water, I took the Weight of that Water. Then, the Pot being emptied and wiped dry, I filled it, ſtrike Meaſure, full of Wheat, firſt ſhaking it well; and having taken the Weight of the Wheat, Water was poured in among the Wheat till it was brim-full; when being weighed again, and the additional Weight of Water, among the Wheat, being deducted from the Pot full of Water only, it was found to be one Seventh, and three Tenths of the Quart of Water; therefore the Sum of the Space for Air to paſs through Wheat is $\frac{1}{7.3}$ of the Bulk of any Quantity of Wheat: A ſufficient Space for Air to paſs through it in good plenty.

107. The Capacity of the Pot being 88.6 Cubick Inches, of which 12.1 Cubick Inches being the Sum of the vacant Space among the Wheat, therefore the remaining 76.5 Cubick Inches is the Space occupied by the Wheat; whence by comparing the reſpective Weights of the Wheat and Water, I found Wheat to be nearly one Tenth heavier than Water.

108. And the Air paſſed as freely thro'

a like depth of Oats, as it did thro' Wheat, and more freely thro' Barley, and ſtill more freely through Peaſe and Beans; between which laſt mentioned Grains there were, on account of their different Shape, larger Interſtices for the Air to paſs, than between the Grains of Wheat and Oats; and this, whether there were at the Bottom of the Trunks a thin metalline Plate full of Holes, or a Hair-Cloth: So that the Floors of Graineries may be covered with either of them. But the fuller of ſmall Holes the Iron Plates are, ſo much the better. But Iron Plate will coſt about twelve Pence a ſquare Foot; Hair-Cloth not two Pence, which is more than ſix times cheaper: but then Iron Plates would be more durable; and will prevent Rats and Mice from coming at the Corn, by Holes through the Floor; and are therefore preferable, eſpecially in large Graineries: They would alſo better bear the Fumes of burning Brimſtone, than Hair-Cloth, when they were to be blown up through the Corn, in order to deſtroy Weevels; but if the Brimſtone Fumes be conveyed to the Valves of the Ventilators by a wooden Trunk, lined a little way with Tin, then at ſuch a diſtance they will not damage the Hair-Cloth, eſpecially conſidering that the Fumigation need be but rarely repeated. And it is found by Experience, that a Hair-Cloth will endure the conſtant Heat of a Malt-Kiln for many Years, without being ſpoiled thereby.

109. Now in order to find with what Force the Air was impelled by the Kitchen Bellows up through the Corn in the Tube A B, *Fig.* 9. I fixed an inverted glaſs Siphon C R I into the ſide of the ſquare wooden Trunk full of Wheat, which was nine and a half Feet high. When the Siphon was fixt half a Foot from the Bottom, the Mercury, by the Preſſure of the Air among the Wheat, deſcended half an Inch below C to R, and aſcended half an Inch above I; ſo that it ſtood an Inch higher in the Leg I than in the Leg R; which ſhowed that the Air among that part of the Wheat, was impelled with a Force, equal to the Weight of an Inch depth of Mercury, which is nearly equal to fourteen Inches depth of Water. When the Bellows were compreſſed very forcibly, then the Mercury would by Vibrations riſe three and a half Inches. When the Siphon was

fixed at three Feet from the Bottom, then the Water inſtead of Mercury in the Siphon was raiſed about two Inches, which was one ſeventh of the former Force. When it was fixed five Feet from the Bottom, the Water was raiſed about an Inch; and at the diſtance of eight and a half Feet from the Bottom, it was raiſed half an Inch; hence we ſee the different Degrees of Compreſſure of the Air at theſe ſeveral depths, in the Wheat. Not that the Velocities of the Air through it, were proportional to the ſeveral Preſſures of it. For the greater Compreſſure of it near the Bottom, was owing to the greater Reſiſtance it met with, from the great height of the Wheat it was to paſs through, which muſt conſiderably rebate its Force as it aſcended higher; but when it had a leſs height of Wheat to paſs through, the nearer it came to the Top, though the Force with which the Air was there impelled was much rebated, yet the Velocity of its Aſcent was increaſed: for when the ſame Experiment was repeated with Peaſe in the Trunk inſtead of Wheat; the Air having a much freer Paſſage through them, aſcended with greater Velocity, notwithſtanding the Compreſſure of it, and conſequently the impelling Force was not in any part near ſo great as in the Wheat.

110. Now hence, ſome Eſtimate may be made of the Force, which will be needful to drive Air up through Corn in Graineries; and as the Force with theſe Corn Ventilators is greater, and the Quantity of Air which will be requiſite much leſs than the Quantity of Air and Velocity with which it is impelled, by the above deſcribed large Ventilators; ſo they may be much leſs, for the uſe of Graineries and Corn-ſhips, which will proportionably leſſen the Labour of working them: But on the other hand, Care muſt be taken that they be not too ſmall, but proportioned to the Size of the Grainery; which will be beſt known by Experience.

111. In theſe Trials with the Kitchen-Bellows, the Air aſcended through the Corn by Fits, only while they were compreſſed. But when the above mentioned large Ventilators, whether double or ſingle, are uſed in Graineries, there will be an inceſſant Breeze of Air aſcending through the Corn;

becauſe the Air under the Corn being in a compreſſed ſtate, by the impulſe of the Bellows, will, by its conſtantly endeavouring to expand itſelf, paſs up through the Corn without intermiſſion.

112. THE Air paſſed through theſe ſeveral kinds of Corn, in the Trunk of nine and a half Feet depth, not only when the Corn lay more looſe at firſt putting in; but alſo when by ſtriking often, on all parts of the Trunk, with a Hammer, it lay the cloſer, though it did not, after this, paſs altogether ſo freely, becauſe it lying cloſer, the vacant Interſtices between the Grains of Corn were the leſs: but all ſorts of Corn muſt neceſſarily, by reaſon of their ſhape, have vacant Interſtices between them, for the Air to paſs through.

Nine and a half Feet depth of Wheat, ſunk on ſhaking $4\frac{1}{2}$ Inches, *viz.* — $\frac{1}{24.4\text{th}}$
Barley, — — — — $\frac{1}{10.2}$
Oats, — — — $\frac{1}{5.5\text{th}}$
Grey Peaſe, — — $\frac{1}{12.8\text{th}}$

Hence we ſee the great difference there is in the Quantities of a Buſhel full of Corn, when unſhaken or ſhaken. 113.

113. THE Ventilators may be fixed againſt the Wall on the inſide or outſide of the Grainery, if there be no convenient adjoining Room fit for that purpoſe; or under the Floor, or to the Ceiling: But whereever they are fixed, the Handle of the Lever, that moves them, muſt be out of the Grainery, elſe the Perſon who worked them, would be in danger of being ſuffocated, when the Corn is fumed with burning Brimſtone, in order to deſtroy Weevels. The ſmall moveable Ventilators, which are deſcribed Number 74, will be very commodious to ventilate Corn in large Bins in Graineries; becauſe they may be moved from Bin to Bin, as wanted.

114. IF the Grainery or Corn-Ship be very long, then the main Air-Pipe may paſs lengthwiſe along the middle of the Grainery, through a large Pipe F G C D *Fig*. 8. and ſo convey Air on both ſides, under the Corn, which lies in Ships, from 20 to 30 Feet broad, and 10 or 12 Feet deep. But wherever the main large Air-Pipe is placed, it muſt not be flat on the Top, but ſloping, like the Ridge of a Houſe, that the

aſcending Air may the better come at the Corn which lies on it.

115. As to the Seams which are between the Boards in the Floors of Corn-Ships, they may eaſily be ſtopped, by the Laths being nailed over them ſo as to prevent the ventilating Air's paſſing any way, but upwards through the Corn: And if any Wet happens to the Corn, it will drain off well through the Hair-Cloth which it lies on.

116. IN Graineries which have large Bins in them, they may each of them have their Laths or Bars to open through the Bottom of the Front Boards: And if Boards be nailed edgewiſe at the Bottom of the Front or Fore-Boards on the outſide of the Bins, they will form three main large Air-Pipes, which will convey Air under all the Bins. Or the moveable Ventilators may be applied to each Bin ſeparately, as occaſion ſhall require to ventilate the Corn in any of the Bins: But when it is needful to deſtroy the Weevels by Fumigation, then the Bellows, or the Handle by which they are worked, muſt be out of the Grainery, elſe the Ope-

rator would be ſuffocated with the Fumes of the burning Brimſtone, as already ſaid.

117. But there is one neceſſary Precaution to be obſerved before any Corn be fumed, *viz.* firſt, to drive out all the damp Vapour which is among it; which would totally quench the Acrimony of the ſulphureous Fumes: which I found to be the Caſe, when a cover'd Gutter had the Fumes of burning Brimſtone blown in great plenty into it, with my ſmall Ventilators, in order to kill Rats. For though the Fumes viſibly paſſed along for many Yards length; yet they were vapid, and did not offend the Noſe, nor kill Animals which were long in it; which was owing to the Damp, which quenches the Acidity of the Fumes.

118. In very large Graineries, there may be ſeveral ſliding Shutters acroſs the main Air-Pipes, whereby only one, or other part of the Grainery may be ventilated at a time; by drawing up or ſhutting down different Shutters, as ſhall be thought proper.

119. If the Grainery be but in part full, then the Air will eſcape ſo freely thro' that

Part which is not covered with Corn, that little of it would aſcend thro' the Corn; to prevent which Inconvenience, that Part of the main Air-Pipe, which leads to the uncovered Part, may be ſtopped by a ſliding Shutter, or a Piece of narrow Board may be run acroſs the Laths, in Paſſages left for that purpoſe: And if there be many of thoſe Paſſages left acroſs the Laths, it will make a better Communication for the Air to paſs freely every way; beſides, that thereby there would be more Space left under the Iron Plate or Hair-Cloth for the Air to paſs up thro' the Corn.

120. IN ſmall Graineries, a very commodious and cheap Ventilator may be made, by making a Ventilator of the Door of the Grainery; which may eaſily be done, by making a circular Skreen of the Size of a Quarter of a Circle, behind the Door: But in order to this, the Door muſt open; not inwards, but out of the Grainery, ſo that as it falls back, it may be worked to and fro, in the Skreen; which muſt be exactly adapted to it in all Parts of the circular Side of the Skreen, as well as at the Top and Bot-

tom. But there muſt be a Stop at about eight or ten Inches diſtance from the Wall, to prevent the Door's falling back farther; that there may be room for a Valve in the Skreen to ſupply it with Air; which Air will be driven by the Door, thro' a Hole made in the Wall near the Floor, into the main Air-Trunk, in which there muſt be another Valve over the Hole in the Wall, to prevent the Return of the Air.

121. WHAT Duſt falls from the Corn between the Laths, will be blown to the farther end of them, whence it ſhould be taken out, before freſh Corn be put in, if the Interſtices of the Laths are at all filled with it.

122. IT is reaſonable to believe, that the Benefits of this Method of preſerving Corn, will be many and great; it will not only preſerve Corn dry and ſweet, and prevent the giving or ſlakening of Malt, which it is apt to do in lying long; but will alſo effectually prevent their being deſtroyed by Weevels or other Inſects: for the heating of Corn, is obſerved much to

promote the Increaſe of Weevels; tho' when the Corn is kept very cloſe, as is ſometimes purpoſely done in Ships, the great Heat and Smother will deſtroy them.

123. NEITHER will the fuming of Malt with burning Brimſtone give any Taſte to the Beer; for tho' I had ſeveral Years ſince tried the Experiment, yet for greater Certainty I now repeated it again, by ſtrongly fuming a Peck of whole Malt, two ſeveral Times, at a Month's diſtance, which being ground, Beer was brewed with it ſeven Days after the ſecond Fumigation, which gave not the leaſt Taſte to the Beer; nor to ſplit Peaſe which were fumed in the ſame manner, as I have formerly obſerved in my *Directions to preſerve Corn, Philoſophical Experiments, p.* 73. The probable Effect of thus fuming Malt will be, that it may prevent the Beer's working too faſt: for this is well known to be the Effect of ſuch Fumes on Wine and Cyder.

124. I FUMED alſo in the ſame manner ſeveral kinds of Grain, as Wheat, Barley, Oats, Beans and Peaſe. I gave an Horſe

a Handful of the Oats ſoon after they were fumed; he boggled at the firſt Smell of the Fume, but eat them immediately. The Scent thus given to the Oats, or any other Grain, will ſoon be carried off by the Ventilation of freſh Air, up thro' the Corn.

(XIV.)

125. IT is uſual for Millers to waſh ſmutty Wheat clean, and afterwards to dry it on a Kiln, in twelve or fourteen Hours, turning it; but then this Kiln-drying often makes it grind unkindly, and not make good Meal: Whereas, after Corn is thus waſhed, and it has drained off, for ſome time, the Groſs of its Wet on a Hair-Cloth laid on Hurdles; if it were afterwards dried by the Ventilation of theſe Bellows, it would then grind as well as other Corn; for drying Wheat with cold Air would not hurt it, as Kiln-drying is found to do. And that I might be well aſſured of the good Effect of thus drying ſmutty Corn, having procured a Quantity of very ſmutty Wheat, which weighed ſeven Pounds and fifteen Ounces; *May* the 26th, at five in the

127. It will be adviſeable to begin to ventilate Corn as ſoon as poſſible after waſhing, that the Moiſture may have the leſs time to ſoak in; for the leſs the Moiſture ſoaks in, ſo much the ſooner the Corn will dry. The inner Part of this Wheat was manifeſtly the ſofter for wetting.

128. AND whereas, waſhed Corn will dry much more ſlowly in a moiſt, than a dry ſtate of the Air, it would be adviſeable to have the Air conveyed thro' a large ſquare wooden Trunk, from the Kitchen, where the Air is dried by the Fire: On which account the Room over the Kitchen would be the moſt commodious to lay the waſhed Corn in, that is to be ventilated. And in caſe the Corn lay in a Room, more diſtant from the Kitchen, the Air might be conveyed thither, to or from the Ventilators thro' a large Trunk.

(XV.)

129. THE firſt large Ventilators which I made, for drying great Quantities of Corn, were at Mr. *William Knight*'s of *Street-*

Street-Houſe in *Farringdon*. The Midriff reſted on its lower Edge, in a Groove which was formed by two Fillets nailed to the Bottom of the Ventilators. In this Poſition, the Midriff, which was ſeven Feet long, and three Feet four Inches broad, was moved to and fro, ſixteen Inches ſideways, that being the Depth of the Ventilators, which were fixed in an upright Poſture breadthwiſe, to the Side of a Garner, which was ſix Feet five Inches long, and four Feet four Inches broad, in all twenty-eight ſquare Feet. The Laths, which were placed on their Edges length-wiſe, under the Hair-Cloth, which covered the Bottom of the Garner, were two Inches deep, and two Inches diſtant from each other: They were all ſupplied with Air, from the large common Air-Trunk which was fixed at one End of them: which Trunk was ſupplied with plenty of Air, from the Valves at one end of the Ventilators, V V, *Fig*. 10. the Air being conducted thence, by a Trunk or Box; the Air entered the Ventilators at their other Ends, by the opening of the like Valves, and not at the Valve Z.

130. THE Midriff was moved to and fro by a Lever, which was fixed to its Iron Tongue S T, *Fig.* 10. and ſtood upright, its lower End being faſtened to the Floor, that being the moſt commodious Poſition for it in that Place.

131. WHEN Corn was laid in this Garner, above two Feet deep, the Air was driven upwards thro' it by the Ventilators, ſo as to raiſe a Handkerchief which was ſpread on it, three or four Inches high, and that all over the Corn: But as the Force of the Air thro' the Corn, was ſomething more at that end of the Garner where it entered; ſo the Corn was laid thickeſt there.

(XVI.)

132. J*ULY* 13th, Twenty-two Buſhels of very ſmutty Wheat were waſhed; in doing of which, when the Corn is poured gently in a thin Stream on the Water, the Smut-Balls having thereby liberty to extricate themſelves from the Wheat, ſwim on the Water, where they are eaſily ſcummed

off; then the Wheat being well ſtirred, and the foul Water let out, freſh Water is poured in, by which means it was ſoon cleanſed. And then, being lain for ſome time on a Hair-Cloth on Hurdles or Harrows, for the Water to drain off, it was put into the Garner, where it lay about 16 and ½ Inches deep.

133. At Nine in the Morning, the Weather being cloudy, with a dry North-Eaſt Wind, we began to blow Air up thro' it, which paſſed very freely. In two Hours the viſible Moiſture was gone, it being partly ſoaked into the Corn, and partly blown off. The next Day about Six in the Evening, it being clear Sun-ſhine, with a dry Wind, the Duſt flew out of the Corn when ſtirred.

134. The third Day, about three in the Afternoon, the lower part being hard enough to grind, it was turned. After this, ſome rainy Days coming, which made the Air within doors ſo moiſt, as to cauſe a great Dampneſs on the Flint-Stone Walls within the Houſe, no progreſs was made in

drying the Wheat, not even by long Ventilation; which I was aſſured of, by putting four Pounds of Wheat into a Hair-Sieve, which was placed on the Wheat, where the Air paſſed freely up thro' it. Hence by weighing this Sieve from time to time, I found what progreſs was made in drying the Wheat, in different States of the Air, as to Moiſture or Dryneſs: For the Corn was found to dry faſteſt in the middle of dry Days, and ſomething ſlower when the Dew fell in the Evening, and till it was gone in the Morning: But in a very damp State of the Air, there was no progreſs made in drying. Hence we ſee how adviſeable it is, where it can be done, to have the Ventilators ſupplied by a Trunk, with the warm Air from the Kitchen. But tho' no progreſs is made in drying Corn thus, in a very damp Air; yet there is ſo large a Proportion of the Times, when the Air is dry enough for the purpoſe, as to make it well worth the while to be provided with theſe Ventilators, eſpecially to dry cold Corn, which will be done much ſooner than waſhed Wheat.

135. HAVING ceaſed to ventilate from *Saturday* Evening to *Monday* Morning, while the Wheat was damp, it was grown muſty; which Muſtineſs was quite gone in three Hours Ventilation, notwithſtanding the Air was very damp. Hence we ſee of how great ſervice this Ventilation will be to ſweeten muſty Corn. Hence alſo we may conclude, that even in damp Weather, the Heating and Muſtineſs of Corn may be prevented, tho' it cannot be then dryed by this means.

136. FINDING that the lower part of the Wheat was dried long before the upper, we took half of it out of the Garner, and then ſoon dryed it, when it was but of half the Thickneſs, and the Air in a drying State.

137. *Sept.* 11th, following, in fine dry Weather ſix Buſhels of ſmutty Wheat were waſhed and dryed fit to grind, with fifty-eight Hours Ventilation. The Corn thus dried was well coloured, and ſold at

the Rate of forty Shillings a Load more than it would have done when ſmutty.

138. IT was very obſervable, that the Air paſſed much more eaſily in moiſt Weather thro' the damp Corn, than when it grew dryer: For the Ventilators required ſenſibly more Force to work them when the Air and Corn were dry, than when wet: which was, as I gueſs, owing to this, *viz.* That the Air and Corn repelled each other more ſtrongly in a dry, than in a moiſt State; which will have the ſame Effect, in cauſing the Air to paſs leſs freely, as if the void Spaces between the Corn were proportionably leſſened.

139. HENCE we ſee one Reaſon among others, why a dry Air exhilarates and chears more than a damp Air, *viz.* becauſe a dry Air being in a more ſtrongly repelling State when inſpired into the Lungs, it thereby dilating their ſmall Veſicles or Air-Bladders, more than a damp Air will, does thereby cauſe a much freer Circulation of the Blood thro' the fine Blood-Veſſels in the Coats of thoſe Air-Bladders: For, that the Blood

paſſes the more freely thro' the Lungs, the more they are dilated, I have ſhown in the Inſtance of the ſighing Horſe; *Statical Eſſays, Vol.* 2. *Exper.* 1. This alſo may be one Cauſe, why a very dry Air is hurtful to thoſe who are conſumptive from weak Lungs; a very dry Air more forcibly dilating the fine Air-Veſicles of the Lungs, than a moiſter Air will do: And perhaps another Reaſon may be, that a very dry Air may carry off too much Moiſture from ſome kind of morbid Lungs. For even the moſt robuſt and healthy are greatly incommoded in their Reſpiration, in a very dry Air; inſomuch, that on the Eaſtern Coaſt of the Red Sea, when the Wind blows from the ſandy Deſarts of *Arabia*, they are obliged to moiſten the Air, by ſprinkling Water, and breathing thro' wet Linnen. And in the Southern Parts of *France*, where the Air is very pure, when it is alſo very cold, they apply, by way of Precaution, a Handkerchief to the Mouth, when they go into the open Air, out of a warm Room, leſt the ſudden Change from hot to cold, ſhould cauſe Inflammations and pleuritick Diſorders, by taking in a full Indraft of cold Air. And *Acoſta* ſays, that the

Air on the Tops of ſome of the *Peruvian* Mountains is ſo very cold, as at one Inſpiration to thicken the Blood.

140. THIS Garner contained but twenty-eight ſquare Feet: If it had been a Square of ten Feet, as it would then have contained a Hundred ſquare Feet; then a Load of Wheat, which is fifty Cubick Feet and a half, would lie but ſix Inches deep on it: That Quantity therefore of cold or wet Wheat might well be dryed at once in a Garner, or on a Floor of that ſize. And Corn thus ventilated may be dryed to the ſame degree, as any other dryed Corn is, by being expoſed in the Ear to a dry Air in the open Field; this ſooner or later, in proportion to the different degree of Dryneſs of the Air.

(XVII.)

141. MILLERS may very commodiouſly dry waſhed Corn thus, and may therefore well allow the Farmer the better Price for ſmutty Wheat; ſince when it is thus dried by Ventilation, it will

be very good, and make good Flour, it not being ſpoiled by drying on a Kiln, which is the Method they have hitherto been obliged to uſe. And the more any Corn is thus dryed, ſo much the better its Meal will keep: which is the Reaſon why they are obliged to kiln-dry the Corn, which is to be ground for Exportation and Ship-Service.

142. In Mills, the Ventilators might be worked by a Crank turned by the great Mill-Wheel, whereby the Expence of Men's Labour might be ſaved.

143. If a warm dry Air, from a proper Stove, were blown thro' waſhed Corn, it would much haſten its drying; and if the Heat of this Air were no greater than that of Sun-ſhine in Summer, it might probably not damage the Corn.

144. The Quantity of Moiſture to be carried off in a Load of waſhed Wheat, is very conſiderable: for ſuppoſe it were but ten Ounces to a Gallon, as it was found to be in the Gallon of waſhed ſmutty Wheat, Numb. (126.) which yet was more, it would then

amount to no leſs than two hundred Pounds weight.

145. AND the ſame Ventilators might alſo be uſed in Mills to winnow Corn very effectually; but then they muſt be larger than when uſed to blow Air upwards through Corn. For I have found on Compariſon, that the above deſcribed large Ventilators convey Air with double the Velocity, that the common circulating Fans, with Sack-Cloths, do. But where theſe Fans are in Mills, turned with a greater Velocity, than is done by Hand in Barns, they winnow ſo much the better.

146. IF ſo great a Quantity as four Ounces of Moiſture can, by two Hours Ventilation, be carried off from a Gallon of wet Wheat; then this Method will doubtleſs much improve what is called cold Wheat, *viz.* ſuch as has grown and been houſed in a cold wet Seaſon: And will therefore doubtleſs ſoon carry off the moiſt Vapours, which ariſe from Corn, and cauſe it to heat and grow muſty. And by thus keeping Corn very dry, it will come the fairer to Market, and be much the better for Uſe.

147. CORN need not be conſtantly thus ventilated, but only now and then. And when it is become once thoroughly dry, then very little Ventilation will be ſufficient.

148. AS ventilated Corn may lie thick without leaving any ſpare Room to turn it, the more Corn may be laid in Graineries already built; and where new ones are to be built, they may be the leſs.

149. THE Expence of turning Corn will be ſaved, and the ventilated Corn will be both ſweeter and dryer than turned Corn can be; by this means even muſty Corn may be ſweetened.

150. THE Expence of Sacks in Ships may be ſaved, or if the Corn be in Sacks, it will keep ſweet, much longer, when the Air between the Sacks is freſh and dry, by the Ventilation of the Ship-Lungs; but this, provided the Corn was not damp, when put into the Sacks. This Ventilation will alſo be of great ſervice to many other kinds of Goods in Ships.

151. SINCE by this means Corn can be ſo effectually preſerved, with little Trouble or Expence; it will doubtleſs be a great encouragement, to lay up large private and publick national Stores in plentiful Years, whereby the great Inconveniences and Miſeries which ariſe from Years of Scarcity, will in a good meaſure be prevented. And the Price of Corn will not for the future be ſo ſubject to great Inequalities, as it has hitherto been.

152. AND this will probably be better both for the Buyer and the Seller: for though in Years of Scarcity, the Farmer will not have ſo very high a Price for the little Corn he has, as formerly when leſs Corn was in ſtore; yet he will be made ample amends for that, in ſelling his great Quantity of Corn, at a much better Price than he uſed to do, to fill the Store-Houſes with Corn.

(XVIII.)

153. THE diſcovering any Means to preſerve the neceſſary Products

of the Earth, ſhould in Reaſon prove a great Benefit to the World in general; yet I ſhould be ſorry to be any ways inſtrumental, in increaſing the Quantity of Corn in the World, if by reaſon of its greater cheapneſs on that account, proportionably greater Quantities of Spirits ſhould be diſtilled from it, to deſtroy Mankind. As things now go in the World, there will in a little time be no occaſion to uſe means to increaſe the Quantity of Corn; ſince the number of the People who are to eat it, daily decreaſes, either by the untimely Death of multitudes, whoſe Vitals are deſtroyed, by theſe hot cauſtick burning Spirits, or on account of great numbers, whoſe Stomachs are thereby ſo depraved, that they can eat little or nothing, to the great detriment of the Landed Intereſt.

154. If Mankind be thus ſupinely ſuffered to be deſtroyed thereby, he ought in Reaſon to be looked upon, as doing the beſt ſervice to the World, who finds means of decreaſing rather than of increaſing, the Quantity of ſo deſtructive a Peſt: which is become an inexhauſtible Fund of Miſery and Ruin to the lower People.

155. IT debilitates and infeebles multitudes of the Laborious Part of Mankind; and its pernicious Effects will be ſeverely felt in the puny Pigmy-Breed of future Generations.

156. BESIDES, the Spirit of Drunkenneſs, which is now ſo prevalent among the Dramiſts, wholly quenches the Spirit of Religion, and depraves the Morals of Mankind. Inſomuch that the Reproof of God Almighty to the Propheteſſes of old, may but too juſtly be applied to this Generation, *viz. Will ye pollute me among my People for handfuls of Barley?* Ezek. xiii. 19.

157. THIS is ſure, greatly to abuſe that large and ample Proviſion that kind Providence has provided for us: 'Tis turning into Poiſon that *Bread* which was graciouſly intended *to ſtrengthen Man's Heart.*

158. AND ſurely ſuch weighty Reaſons ought to rouſe the Governours of the Nations, as tender Fathers, to uſe their utmoſt Endeavours to deliver the People, committed to their charge, from this mighty Deſtroyer.

Can there be any Conſiderations of ſufficient weight to the contrary? And will not this, in the end, be found the moſt effectual means to increaſe the real Wealth and Strength of a Nation? But what need of Expoſtulation in a ſelf-evident caſe, which ſtrikes in ſo ſtrong and glaring a manner, that not only every open willing Eye, but even the wilfully blind, cannot but ſee the Miſeries it brings on a great part of Mankind; as is evident to daily and conſtant Obſervation and Experience, in thouſands of Inſtances.

(XIX.)

159. BUT to return from this important Digreſſion, while I was thinking how to make theſe Ventilators uſeful in drying damp Mows or Ricks of Corn, and thereby to prevent their firing, or the Mow burning of the Corn, which too frequently happens in wet Harveſts; but finding this impracticable on account of the largeneſs of the Ventilators, the following Method of doing it occurred to me; *viz.* When a Well is made in the middle of a Mow of Corn (as is the known Practice) I would

propoſe this farther Improvement; *viz.* about four or five Feet from the Ground, to leave four horizontal Paſſages, a Foot ſquare, oppoſite to each other, two of them leading from the Well lengthwiſe to the ends of the Mow, and two of them breadthwiſe to the ſides; and to make Holes through the Boards, at the ſides and ends of the Barns, for theſe Paſſages to communicate with the freſh open Air, which would by this means paſs freely through the Corn-Mows; and it would alſo paſs moſt freely up through the Well, if all the Holes are cloſed, except that at which the Wind enters. Thus, ſuppoſe the Wind to blow againſt the fore part of the Barn, then let the Holes on the oppoſite ſide of the Barn be cloſed with Shutters which move on Hinges faſtened to their upper ſide, which Poſition will prevent the enterance of Rain, when the Shutters are open. By this means, the Vapours which ſteam from the Corn into the Well, will be carried off in a manner, as faſt as thoſe which ariſe from the outſides of Ricks, that ſtand in the open Air; whereby the Corn in the middle of the Mow will be dried near as faſt, and to as great a depth from the ſides of the Well, as at the outſides.

160. In order to make trial of this Method, I provided Cradles, made of four Aſhen Poles, which were faſtened, at a Foot diſtance from each other, with Ledgers or Rounds, making thereby ſquare oblong Cradles, like four Ladders joined together. The end of the Barn where the Corn lies, being twenty eight Feet wide each way, and the Well in the middle three Feet acroſs, theſe Cradles reached from the Well to the end and both ſides of the Barn; where Holes were made through the outſide Boards a Foot and half broad, and two Feet long from Bottom to Top, thereby to make a ſufficient allowance for the ſinking of the Cradles with the Mow. On which account, the Bottoms of the Cradles muſt at firſt be placed even with the upper parts of the Holes in the outſide Boards.

161. This end of the Barn was filled with Barley, in a wet Seaſon, and lain very wet in the Mow, much wetter than they would otherwiſe have done, preſuming that the Well and Cradles would prevent its getting any Damage. When they threſhed this Barley in *November* and *December*, the upper part of the Mow was in a good Con-

dition, and, though lain in ſo wet, the Well and Cradles prevented its heating and Mow-burning. But as it was lain in very wet, and did not heat ſo as to make it ſweat off its Moiſture, it grew mouldy, ſo that the Barley-Ears were covered with a white Fenn. From the Well in the middle of the Mow, to the Barn-Floor, there was lain for Trial-ſake, a long Range of Faggots, conſiſting of three Rows of them, lain on each other: But the Faggots being ſmall, and the Wood ſtraight and even, there was very ſmall Paſſage for Air; whereas if they had been made of a rougher Wood, there would have been a freer Paſſage for Air: The event was, that the Corn was matted together and grown near the Faggots; but about the Cradles it was dryer and better, yet this did not reach far.

162. THUS, I have given an account of the Event of this Trial with Cradles, that the skilful Farmers may judge, how far they may, or may not be of ſervice to them in Mows or Ricks of different ſizes, and different degrees of wetneſs or dryneſs: For according as theſe Circumſtances vary, they may

be more or leſs beneficial, or even hurtful; for ſome degree of heating in the Mow is of uſe to give Warmth enough, to cauſe the Moiſture to go off in a Wreak. It cannot be inferred from this Trial, that theſe Cradles will be of no ſervice in any Caſe; for this Barley was ſo very wet, that without the Cradles it would not only have been in danger of being Mow-burnt, but alſo of firing. As theſe Cradles do in effect divide a large Mow into four ſmaller ones, they will therefore be of uſe, where the Corn, when firſt lain in, has ſuch a degree of Dampneſs, as would be too much for it, in a large Mow; but would do well in a ſmaller Mow or Rick, and may alſo contribute to make Corn, which is lain pretty dry into a Mow or Rick, the dryer.

163. I HAVE found on Trial, that undryed Gun-Powder may be as throughly dryed, by thus blowing Air up through it, as in the very dangerous hot Fire-Stoves of the Powder-makers. For, having found, that Air blown from a common pair of Kitchen-Bellows, would paſs very freely up through ſixteen Inches depth of Gun-Powder, ſo as

to raiſe up a piece of Paper that lay on it; I acquainted Mr. *Norman*, Owner of the Powder-Mills at *Moulſey*, near *Hampton-Court*, with this; who ſent me his chief Clerk with twelve Pounds of undryed Powder; which we put into a Box, where it lay ſeven Inches deep on a Cheeſe-Cloth, which reſted on a Laceing of Packthread, an Inch and half from the Bottom of the Box.

164. January the 20th, having fixed in an oppoſite Poſition, the Noſes of two Pair of Kitchen-Bellows, in Holes made thro' the Box, under the Cheeſe-Cloth, Air was blown forcibly up through the Gun-Powder, and every two Hours the Box was weighed, to ſee how much it decreaſed in weight from time to time. The total Decreaſe of Weight, by the Evaporation of the Moiſture, and flying off of Duſt, and of ſome Grains of the Powder, was, in twenty Hours blowing, one Pound ſix Ounces. Six Pounds of the like Powder, being dryed in the hot Stove at the Powder-Mills, decreaſed in weight five Ounces and a half; hence, nearly half the waſte in this Operation with Bellows, was by the flying off of the Duſt, and ſome of

the Grains of the Powder; which Duſt will moſt of it be ſaved, in large drying Rooms, made fit for that purpoſe.

165. Now the Powder thus ventilated was thereby ſo fully dryed, that on Trial with the *Proof* Inſtrument, it was found to be as ſtrong, as ſome of the ſame Powder, juſt then dryed, as much as it could be by Fire.

166. March 30th following, the Air very dry with an eaſterly Wind, I repeated the ſame Experiment, with twelve Pounds of undryed Cannon Powder; which Mr. *Underhill* ſent me from his Powder-Mills on *Hounſlow-Heath*: it was put into a Box of ſuch a Size that it lay 2 and $\frac{1}{2}$ Inches thick. It waſted in the firſt two Hours Ventilation near two Ounces: Happening, after an Hour and three Quarters more Ventilation, to ſtir the Powder with my Fingers to the Bottom, the Duſt roſe in thick Clouds where I ſtirred, but not without ſtirring: It was well dried in ſix Hours, and tho' it was ventilated on for eight Hours more, yet it did not prove ſenſibly ſtronger on Trial,

than that which had been ventilated only ſix Hours. When theſe thus dryed Powders, either after ſix or fourteen Hours Ventilation were compared, by Mr. *Underhill* and his Clerks, with ſome of the ſame Powder dryed in his Stove; the latter raiſed the Proof-Inſtrument to two Degrees, and the former, but to one and three Quarters: the reaſon of which Difference, we found on repeated Trials to be this, *viz.* that ſome of the ſmaller Powder, being by Ventilation ſeparated from among the larger Grains, its Strength was not ſo great: For when we tryed ſome of the ſmaller Powder, it then exceeded the Force of the Stove-Powder, it raiſing the Proof-Inſtrument two and a half Degrees, which was half a Degree more than it roſe with the Stove-Powder; ſo that it may be looked on to be as thoroughly dryed as the Stove-dryed Powder: It is found by Experience, that *cæteris paribus*, the ſmaller the Corn of the Powder is, ſo much the greater will its Force be.

167. AND ſince the Duſt in this Operation did not riſe, unleſs when ſtirred, therefore it will be beſt to avoid ſtirring the

Powder, while it is ventilating: And as to what falls thro' the Canvas, it may be mixed with the Powder, after it is thoroughly ventilated: There was about a Pound of the finer Corns, which were found under the Canvas, having dropped through its Pores.

168. By comparing this Trial with that which was made in *January*, we may obſerve, that the different State of the Air, as to Moiſture and Dryneſs, has a conſiderable Influence, in haſtening or retarding the drying of the Powder. And I obſerved the ſame in drying of Malt and Wheat; that early in the Morning, they did not waſte near ſo much as in Mid-day. But if inſtead of cold Air, the Powder be ventilated with a hot Air from a Stove, which is heated by a Fire in an Iron *Cockle*, as is done in ſome Hop-Kilns, then the Powder would probably be effectually dryed, in an Hour or two, ſooner or later, in proportion to the Degree of Heat of the Air; and this, tho' it lay of a great Thickneſs: And we ſee in the Caſe of ventilated Hops, that great Quantities of hot Air may eaſily be had from a proper Stove. And as it would

be dryed ſo ſoon, it would ſave a great Expence of Fewel: And would alſo be done with much Safety from firing; for the hot Air might be conveyed from the Stove, thro' a large ſquare wooden Trunk, to the Place where the Powder is, at any Diſtance that ſhall be thought proper. And that the Trunk might not be affected by the Coldneſs or Moiſture of the Weather, it might be covered with another like Trunk of Boards, at about an Inch diſtance from the inner Trunk; the outer Trunk to be tarred to keep out Moiſture. In this Situation, there would be little Danger of firing the Powder, even tho' the Stove ſhould by accident take fire.

169. AND ſince undryed Powder can by this means be dryed to ſuch a Degree; Barrels of Gun-Powder which lie in Store-Houſes and Magazines, eſpecially in damp Countries, may by the ſame Means, doubtleſs, be kept very dry: For as the Liquor in Casks waſtes conſiderably by its ſoaking thro' the Wood, and perſpiring away; ſo, on the contrary, if Powder-Barrels are in a moiſt Place, the Moiſture muſt needs ſoak

thro' them and damage the Powder. But this may effectually be prevented, if great Quantities of freſh Air be, by means of ſuch large Ventilators, conveyed into Magazines of Powder, in dry Days, and in the dryeſt Part of thoſe Days. And when Powder is kept very dry, it has been found by Experience to retain its Virtue and Force for above fifty Years. And when once the Magazines are thus thoroughly dryed, it is probable that a little Ventilation now and then, for a few Hours, may ſuffice; ſo that the Expence of Labour will not be great.

170. AND if it ſhall be needful to convey Air to the ſeveral Corners of the Magazine; this may be done by very large ſquare or round Trunks, made of Canvas or Tarpaulin, which will be both better than Boards, becauſe ſome Air will get all along thro' their Subſtance; which one would chuſe to have it do, where there will be ſo great Plenty of it: and the Canvas will laſt long in ſo dry a State.

171. AND as the Powder in the Powder-Room in Ships, is ſubject to be damp, ſo

that, as I am credibly informed, in long Voyages, they bring the Barrels of Powder above Deck, in order to dry them in the Heat of the Day; and in *Engliſh* Ships, they have the Powder-Room under the Kitchen, as being the dryeſt Place. Now it may with the greateſt Eaſe be kept dry in Ships, by conveying freſh Air into the Powder-Room, in the Middle of dry Days, with the abovementioned ſmall Ventilators, Numb. 72.

(XX.)

172. AIR is one of the great Inſtruments of Nature, by the Motion of which, it is not only rendered wholeſome, but is thereby alſo made inſtrumental in being ſerviceable to all the Products of the Earth: For it not only, by its Ventilation carries off the great Quantity of Vapour, which perſpires from all kinds of Vegetables, which if left to ſtagnate around them, would ſuffocate them and produce Mildews, *&c.* But it alſo greatly contributes to the gentle drying of the Subſtance of growing Vegetables, whereby they are not only enabled

to attract vigorouſly freſh Nouriſhment, but alſo grow thereby gradually more and more firm and hard.

173. DR. DESAGULIERS in his Experiments on *Electricity* obſerves, that a dry Air is very *Electrical*, by which Property it attracts Moiſture ſtrongly: Thus a Glaſs Tube excited to *Electricity* by rubbing, will not only forcibly attract little Drops of Water to it, but will alſo draw a ſmall Stream of falling Water of $\frac{1}{10}$th Inch Diameter from a Perpendicular to a Curve. No wonder then, that Air in paſſing up thro' Gun-Powder, for a Continuance, ſhould dry it ſo perfectly well.

174. HAVING therefore found Means to put great Quantities of Air in Motion, with Eaſe; we may doubtleſs in Imitation of Nature, make it beneficial to us in many Reſpects. Thus it might be of uſe in ſeveral Trades, to carry off the noxious Vapours of the Materials which they are working upon, by a large Stream of freſh Air.

175. THEY may alſo be of conſiderable Uſe to publick Brewers in hot calm Weather; when, as I am informed, whole Brewings of Beer are ſometimes ſpoiled for want of Motion in the Air, to carry off the Wreak, which not only damages it, by dropping down again into the Wort in the Coolers, but alſo retards its cooling; and by being thus kept too long warm, makes it work unkindly in the Tun.

176. I HAVE been informed by an Upholder, that large Stores of Feathers are very apt to ſpoil, for want of freſh Air; which Inconvenience, this Ventilation would not only effectually prevent, but would alſo make the Feathers much lighter and ſofter for uſe.

177. THE Ventilation of freſh Air, contributes alſo much to the preſerving Woollen Goods free from Moths, and would therefore preſerve Wooll in Stores.

178. THESE Ventilators will alſo be of ſervice to ventilate large Rooms with freſh

Air, in hot Climates, and that more effectually, and with leſs Labour, than it is at preſent done with large Fans. And ſuch Ventilation is refreſhing, even tho' the ventilating Air, which ſurrounds the Perſons, be as hot as before any Ventilation was made; for Breezes refreſh in hot Climates, *viz.* becauſe thereby the frowzy Vapours, which exhaled from thoſe Perſons, being carried off, a freer Perſpiration is thereby promoted, which refreſhes and exhilarates. And for the ſame Reaſon, it would probably be of good ſervice to the Sick in Hoſpitals and private Chambers; if their frowzy rancid Air, (which incommodes the Sick more than many are aware of) could be exchanged for dry, pure, warm Air.

(XXI.)

179. IN order to try of what uſe theſe Ventilators would be in drying Hops; I went to Sir *Thomas Hales*'s at *Howletts* near *Canterbury*, where there are four adjoining Kilns in one Building, which have Cockles of caſt Iron fixed in the middle of them. They ſtand on Brick-work about

thirty Inches from the Ground, and are two Feet four Inches high; two Feet nine Inches broad in Front, and two Feet eleven Inches long backward; with a leſſer Iron Box, which covers a Hole on the Top behind; which Box is two Feet three Inches long in Front, ten Inches broad and deep: At the Back of this upper Box, is a large Hole thro' which the Smoke is conveyed by Brick Funnels, quite round the upper Part of the Kilns, and thence paſſes off thro' an upright Chimney; by which means the Smoke of the *Newcaſtle* Coal, which is the Fewel, cannot damage the Hops. The Diſtance of the upper Surface of the Cockle from the Hair-Cloth, on which the Hops lie, is ſix Feet ſeven Inches.

180. To the Outſide of a Kiln, I fixed a Pair of Ventilators, in an upright Poſture; which are here deſcribed in *Fig.* (10.) I, K, O, O, M, N. They were made eight Feet long in the Clear within ſide, from A to C; four Feet ſeven Inches high from A to P; their Depth within from C to D, was ſixteen and a half Inches; ſo that there was room for the upper Part of the Midriff to move to and fro ſixteen Inches; an Allowance be-

ing made of half an Inch, for the Thickneſs of the Midriff, which was made of Deal-Boards half-inch thick, laid length-wiſe from C to A, and faſtened together with broad Battings, which at each End were half-inch thick, but that in the Middle was an Inch thick, for greater Strength; the Iron Tongue S T being here ſcrewed faſt to it, about eight Inches from the Top, with an Iron Plate on each ſide; it had a Joint at the Midriff every way moveable, that thereby it might the better comply, both with the Motion of the Midriff, and alſo of the Lever G F, to which it was fixed by an Iron Pin, in a Mortice at T. The Length of the Lever, which was fixed at G with a moveable Joint, was three Feet long from G to T, and eight Feet ſix Inches from T to F, the End which was worked to and fro by Mens Hands, in a horizontal Poſture; a ſmall Wheel of four Inches Diameter being fixed to it at R, that it might move the more eaſily on the Board X X, which it reſted on: There were alſo at X X, Checks to ſtop the Lever, at its utmoſt Vibrations, thereby to prevent the breaking the Ventilators in working the Midriff to and fro.

181. THE Midriff ſtanding thus edgewiſe, had no need of Hinges, but reſted in a Groove, which was formed by Fillets nailed on each ſide of it: And to prevent the wearing away of its lower Edge, by much motion to and fro, there were Iron Laps, three Inches broad, one in the Middle, and one towards each End, nailed round its Bottom; which Laps reſted on Iron Plates, let into the Bottom Boards: And alſo the like Iron Laps at each End, near the lower Corners, which worked againſt the like Iron Plates, to prevent the Midriffs bearing at either End, againſt the End-Boards, which would make them move very heavily.

182. THE outward Boards of the Ventilators were all, excepting the Cover, made of inch-thick Deal, and their Edges well joined with Grooves and Tongues in them; the Cover or upper Boards, were only half-inch thick, that they might the better bend into a Circular Form, in which Form they were fixed by Circular Battings on their Outſide: All the Joinings of the Boards had ſtrong brown Paper paſted on them, and

thoſe of the Midriff on both ſides. The Coverings were made of Fir-Boards half-inch thick, with Circular Battings Q Q, both to make them retain their Circular Form, and to ſtrengthen them.

183. THE Valves at which the Air entered, were made on the fore-ſides of the Ventilators at Z, and juſt oppoſite on their back-ſide, where they could be made very large; for the larger and lighter the Valves be, ſo much the eaſier the Ventilators work; if they are between a fortieth and a fiftieth Part of the Breadth of the Midriff, they will do well. As to the Valves thro' which the Air paſſed out of the Ventilators, there was a Neceſſity for having them, at the End U U; where, by being too ſmall, it cauſed the Ventilators to work ſo much the harder; whence the Air was conveyed by a large Box B, M, N, up to the large ſhort Trunk X, thro' which it ruſhed into the Kiln: One half of the Stream of Air, beating againſt the Side of the hot Cockle, was thereby ſpread ſideways, backwards, as well as upwards; the other half of the Stream of Air went directly forward, cloſe by the

Front of the Kiln, and then turned round the other ſide of the Cockle, as well as upwards, whereby this cold Air was ſoon warmed: By which means it was ſpread, ſo as to paſs pretty uniformly up thro' all parts of the Hops.

184. There was alſo another Paſſage made, for the Air of that half of the Ventilators which was next to the Kiln, to be conveyed by a Trunk, into the Kiln behind. When this Method is uſed, then its other Valve U muſt be ſtopped, by a Stick thruſt againſt it, thro' a ſmall Hole, in the Side of a Box, which is oppoſite to it. By this means, the Air may be conveyed, partly one way, and partly the other, as ſhall be found beſt.

185. I Fixed alſo in the ſame manner, juſt oppoſite to theſe, a like Pair of Ventilators, to the Side of the adjoining Kiln, which was eight Feet diſtant from the other; ſo that by the Motion of the Lever G T F, which was in the Middle between them, Air was conveyed at the ſame time into

both Kilns, by the Work of two Men, who were at Times to be relieved.

186. THE great Quantity of Air conveyed thereby, may be thus eſtimated; one of theſe Ventilators, containing nearly Forty-eight Cubick Feet: the half of which Quantity being driven out at each Stroke, *viz.* twenty-four Cubick Feet; this at ſixty Strokes in a Minute, will be thirty-ſix Tuns in a Minute, which amounts to Two Thouſand one Hundred and Sixty Tuns in an Hour, if all the Air contained in the Ventilators paſſed off thro' the Valves: but as ſome eſcapes by the Edges of the Midriffs, an Allowance muſt be made for that; which ſuppoſing it to be one Tenth of the Whole, then One Thouſand nine Hundred and forty-four Tuns of Air in an Hour are conveyed, which ruſhed into the Kiln very briskly; inſomuch, that if a very thin light Handkerchief was ſpread on the Hops, it was very ſenſibly moved. The ſame thing might alſo ſometimes be obſerved, when there was no Ventilation, *viz.* when the Wind ſet ſo as to blow briskly into the Kiln.

187. BUT notwithſtanding this great Quantity of Air was thus conveyed in by the Ventilators, yet it was very obſervable, that there was a conſiderable Indraft of Air, at the Entrance of the Kiln, which was ſeven Feet high and two Feet wide: for if a Handkerchief was held there, it was drawn inwards by the Indraft of the Air; yet it was very ſenſibly leſs, when the Ventilators conveyed Air in, than when they did not.

(XXII.)

188. THERE are uſually dryed on theſe and the like Kilns of ſixteen Feet ſquare, ſixty Buſhels of Hops in twelve Hours. *September* the 7th, eighty Buſhels of wet Hops were dryed by Mr. *Baker* of *Sandwich*, a very skilful Malſter and Hop-dryer, in ſix Hours and forty Minutes, fine coloured, ſoft, and well dryed.

189. SEPTEMBER the 8th, an Hundred Buſhels were dryed by him, in ſeven and a half Hours, fair and good conditioned.

190. SEPTEMBER the 9th, in order to try what Effect the united Air of both Pair of Ventilators would have; by a Trunk of Communication at X X, the Air of both Pair was conveyed into one Kiln; it being ſtopped from paſſing into the other Kiln: And there were ſliding Shutters made to ſtop or open this Trunk of Communication when required. An Hundred Buſhels of Hops were thus dryed, by the common Dryer, in ſix Hours, but they were not well coloured.

191. SEPTEMBER the 10th, 120 Buſhels of damp cold Hops (it being a very cold damp Morning when they were picked) were dryed by Mr. *Baker*, in eight Hours, with the double Ventilators, fair, fine, and thorough dryed.

192. HENCE we ſee the good effect of conveying great Quantities of Air, up thro' Hops, while they are drying, and that eſpecially when in calm moiſt Weather being wet (which is often the caſe of Hops) they are in danger of being diſcoloured and

ſpoiled, by ſcalding and ſtewing long in their damp Wreak: Now Air being the wings, on which damp Vapours aſcend, the greater the Plenty of Air, ſo much the ſooner, as it is well known, will any thing be dryed; eſpecially when that Air is not only dry, but hot too.

193. DID the Wind conſtantly blow briskly, through the whole or greateſt part of Hop-Seaſons, there might be a ſufficient Quantity of cold Air conveyed into the Hop-Kilns, without Ventilators; for it was obſerved (N° 186.) above, that when a brisk Eddy of Wind blew in at the Kiln-Door, it moved a Handkerchief lain on the Hops, as much as the Air from the Ventilators did. And therefore it will be of good ſervice to Hop and Malt-dryers, whether they have Ventilators or no; not only to make a large Stoke-Hole or Fire-Place, for Plenty of Air to enter into the Kiln; but alſo to make large Inlets, on every ſide, if poſſible, of the Room in which the Kiln ſtands; that which way ſoever the Wind blows, it may have a free entrance; and being, by cloſing the Openings on the other ſides of the Room,

hindered from paſſing out again, it will be driven in plenty into the Kiln, or up thro' the Hops: and as there are frequently Winds in the Hop-Seaſon, this Method will be very ſerviceable in drying them. But in wet and calm Seaſons, theſe Inlets for the Air will be of little ſervice; at which times the Ventilators will be moſt of all neceſſary. The having proper Cowls on the Tops of the Kilns, to promote the conveying off of the hot Air and Steam, will greatly promote the freer Entrance of Air below.

194. BUT there is an Error, which ſome Hop and Malt-dryers are apt to fall into, *viz.* they ſeeing that the more a Fire is narrowed in, at the Fire-Place, ſo much the brisker it burns; are apt thence to conclude, that there is thereby, not only a ſtronger Fire, but alſo a greater Indraft of Air, becauſe they obſerve the Air to ruſh in faſter, through and over the Fire, when the Fire-Place is narrow, than when wide: which is juſt ſuch a miſtaken way of Reaſoning, as if a Man who ſees Soldiers, for greater Diſpatch, running through a Lane or narrow Defilée, ſhould therefore conclude, that a whole

Army could march ſooner thus, through a narrow Paſs, than over an open Plain, walking only a Foot-Pace. It is accordingly obſerved that ſuch narrow Fire-Places are apter to give a ſcorching Heat, than wider ones; the Reaſon of which is, that the narow ones give Heat with little Air, the wider ones Heat with a greater Plenty of Air, to carry off the damp Vapours.

195. Now notwithſtanding this great Quantity of cold Air, was conveyed into the hot Kiln, both from the Ventilators, and from the Indraft, at the Kiln-Door, yet it paſſed hot up through the Hops, in proportion to the different degrees of Heat that there was in the Kiln; for ſo rare and light a Body as Air, both heats and cools very ſoon.

196. Hence we ſee, how eaſy it is to procure a great Quantity of hot Air, in order to dry any kinds of Goods with it, by means of Ventilators: for if notwithſtanding the great Quantities of cold Air which entered the hot Kiln, it yet paſſed up hot through the Hops; then doubtleſs in like manner great Quantities of hot Air may be drawn by Ventilators from a hot Stove, to be con-

veyed thereby to any Goods that are to be dryed.

197. I Took the Degree of Heat, among the drying Hops, by a mercurial Thermometer, which was graduated according to *Farenheits*, in which the freezing Point is thirty two Degrees, Blood-Heat ninety ſix, and the Heat of boiling Water 212. This Thermometer was graduated to 300 ſuch Degrees. I found the Heat of noon-tide Sun-ſhine at the end of *Auguſt*, under a Wall 102 Degrees. But as the freezing Point is a fixed determinate Point; I ſhall begin the Graduation thence, deducing the thirty two Degrees below freezing, with which this Thermometer begins: And then Blood-Heat will be ſixty four Degrees above Freezing, noon-tide Sun-ſhine 70, and that of boiling Water 180.

198. September the 9th, after two Hours drying with Ventilation, the Heat at the Bottom of the Hops, next the Hair-Cloth between the Bars of Laths, was 120 Degrees, *viz.* two thirds of the Heat of boiling Water. In the middle of the Hops the Degree of Heat

was 76, on the Top of the Hops, 60 Degrees, ſeven Feet above the Hops 63 Degrees, it being uſually two or three Degrees hotter there, than on the Surface of the Hops. And this ſixty three degrees of Heat, *viz.* nearly Blood-Heat, was very irkſome and incommodious, to continue in for a time: Much more ſo than the abovementioned 70 Degrees of Heat, in dry hot Sun-ſhine: The great irkſomeneſs of this leſſer damp Heat, being occaſioned, not only by incommoding the Reſpiration, with a foul Air, but alſo by relaxing the Surface of the Body, by this damp Air. And the like difference is commonly obſerved, between a damp and a dry cold Air; the former with a leſs degree of Cold incommoding us much more than the latter, with a much greater degree of Cold. Now the raiſing the Heat to 120 Degrees in ſo ſhort a time as two Hours, proved too great a Heat, eſpecially with wet Hops, for they were not well coloured, Numb. 190.

199. SEPTEMBER the 10th, when 120 Buſhels were well dryed with Ventilation; after two Hours and a half, the Heat at the Hair-Cloth was 118, in the middle of the

Hops 66, on their Surface 62; half an Hour after, *viz.* at the end of three Hours drying, the Heat at the Bottom of the Hops was abated ſix Degrees, *viz.* to 112; at five Hours end it was riſen to 117, and was 80 on the Hops. At the end of the drying, which was in eight Hours, the Heat at the Hair-Cloth was abated to 88, and yet the Cockle was very red-hot, much more than any time before, during the drying of this Kiln of Hops. Since then denſe Vapours among the Hops acquire a greater degree of Heat than this, with a cooler Cockle; therefore the greateſt Care and Skill is needful while they are damp. And here ſeems to be one of the principal Uſes and Benefits of theſe Ventilators, *viz.* to carry off the Moiſture the faſter, and thereby to leſſen both the Quantity of it, and the Time of the Hops ſtewing in it. Another conſiderable Benefit of them is, that they dry Hops in much leſs time, and conſequently not only leſs Fewel, but alſo fewer Kilns will be needful, where ſeveral are uſed.

200. By comparing at ſeveral times, the different Degrees of Heat, given to venti-

lated and unventilated Hops, I found that the ventilated Hops at equal Times, from their being firſt laid on the Kilns, could bear conſiderably greater Degrees of Heat, than the unventilated ones.

201. BY the help of ſuch a Thermometer, many uſeful Obſervations might be made, in relation to the different Degrees of Heat, which wet Hops, or thoſe which are not wet, require, in different Stages of their drying.

(XXIII.)

202. I HAVE here given an account of theſe Ventilators which are to be worked by Men's Labour; becauſe they may poſſibly be of ſervice in ſome Hop or Malt-Kilns, to carry off the main Damp, eſpecially in moiſt Weather, when by a few Hours working they will do much good: but it would be too laborious and expenſive to have Men work them during the whole time of drying. It is propoſed therefore to have four Pair of Ventilators fixed upright on one end, under a Lodge or

Shed at the back of the Houſe in which the above mentioned four Kilns are; each of the Ventilators to be ten or twelve Feet high, and ſix Feet wide, and ſeventeen and a half Inches deep; that the Midriffs may have room to move to and fro ſixteen Inches, leaving half an Inch to ſpare on each ſide, to prevent their beating againſt the Ventilators, and thereby damaging them.

203. THEY are to be worked to and fro by the Labour of a Horſe fixed to an horizontal Cog-Wheel, as in *Fig.* 11. the Cog-Wheel K K to be twelve Feet in Diameter, and the Arm or Lever I, by which the Horſe turns it round, to be ten Feet long; the Drums or Wallowers D, F, to be eighteen Inches in Diameter, which by their Axle-Tree turn the Crank B, whoſe Crook is to be eight Inches, which will give a Motion of ſixteen Inches to and fro to the Midriffs, by means of a Rod or Pole fixed to the Crank and to the Lever at F or G, *Fig.* 4.

204. AND the Crank muſt be made to be turned by the Axle-Tree of the Wallowers or not, at pleaſure, by means of a

ſquare Iron-Box C or E; which by ſliding on or off, is made to take hold of the ſquare end of the Axle-Tree, on which the Drum-Wallower turns.

205. For as the great Cog-Wheel, by ſtanding in the middle between the four Ventilators, is to have a Wallower and Crank of each ſide; ſo by means of theſe ſliding Iron-Boxes, either all the Ventilators may be worked at the ſame time, or only two Pair of them, as occaſion ſhall require.

206. The Crooks of the Cranks when working muſt not ſtand both the ſame way; but they muſt be ſo fixed by the ſliding Iron-Boxes, that when one of the Crooks is at the top or bottom of its Circle, the other muſt be ſide-ways, directly at right Angles to each other. This Poſition will prevent the heavieſt and moſt laborious Parts, in the Motion of each Crank, from coming together, which will make it the eaſier for the Horſe to turn them. The Air to be conveyed thence through Valves and Paſſages formed in the ſame manner as thoſe in *Fig.* 4, and 5.

207. G is a Section of the main Beam in which the Gudgeons of the Axle-Trees of the great Cog-Wheel, and of the two Wallowers do turn; the Gudgeons of their other ends being at A, *&c.*

208. THE Ventilators muſt ſtand about fourteen Inches from the Wall of the Houſe, that there may be room for Trunks of a Foot ſquare within, which are to lead thro' to the back of the Kilns, and alſo to leave room for large Valves for the Air to enter the Ventilators, of ſeven Inches depth, and two Feet long.

209. BUT the Air of both Pair of Ventilators is not to paſs in this Caſe, as in *Fig.* 5 at T Q, into one common Trunk; but it is to paſs out at B L K M, *Fig.* 4. near their outſides, into ſeparate Trunks behind; each pair of Ventilators being to ſupply their reſpective Kiln with Air. The other Wallower F is to turn another Crank, which is to work the two other Ventilators.

210. NOW to make ſome Eſtimate of the great Quantities of Air, which will thereby be conveyed into each of the four Kilns: It is found by Experience that Horſes, one with another, can draw a Force equal to 200 Pounds weight, for eight Hours in a Day; walking at the rate of about two Miles, and three Tenths, in an Hour; which is about three Feet and a half in a Second of Time, or the ſixtieth part of a Minute. And if the ſame Horſe is made to draw 240 Pounds, he can work but ſix Hours in a Day; and cannot go quite ſo faſt. See Dr. *Deſaguliers*'s *Courſe of Experimental Philoſophy*, p. 241. And p. 243, he ſays he has found, that five Men are equal in Strength to one Horſe, and can with the ſame Eaſe puſh round the horizontal Arm, in a Walk of forty Feet Diameter; which he ſays, ſhould never be leſs, where there is room for it; that being much eaſier for a Horſe to walk in, than a nineteen-Feet Walk: For he obſerves, that three Men will puſh round an Arm, in a 19 Feet Walk, which an Horſe, otherwiſe equal to five Men, can but draw round. But though a 40 Feet Walk would

be better for the Horſe, than one of 19 Feet, on account of his turning continually too ſhort; yet in this Caſe there is a Neceſſity for uſing the latter, becauſe the former would make the Lodge too large. A Man of 140 Pounds Weight drawing a Boat, by a Rope coming over his Shoulders, cannot draw above 27 Pounds, which is about one ſeventh Part of what a Horſe can draw in that Caſe. *ib.*

211. SINCE then a Horſe can walk, drawing for eight Hours 200 Weight, at the rate of two Miles and three Tenths, or 12600 Feet in an Hour; which will make in his Circumference of 57 Feet (allowing the Diameter of his Walk to be 19 Feet) 222 Revolutions in an Hour: And the great horizontal Cog-Wheel being 36 Feet in Circumference, its Circumference goes round at the rate of 7992 Feet in an Hour; which divided by four, the Circumference of the Wallower at its Rounds or Cogs, gives 1998 Revolutions of the Cranks in an Hour, which is at the rate of 33 Revolutions in a Minute.

212. WHICH ſuppoſing the Ventilators to be each ten Feet high and five Feet wide, will be twenty two and a half Feet of Air at a Stroke, allowing as above (Numb. 186) one Tenth of the Air to eſcape at the Edges of the Midriffs; and each Revolution of the Cranks giving two Strokes, that will be ſixty ſix in a Minute, and two Thouſand two Hundred and twenty ſeven Tuns, which each of the four Ventilators will convey into each Kiln in an Hour; that is 283 Tuns more than the Hand-Ventilators Numb. 186. do convey, in the ſame Time. And if theſe Ventilators are made 12 Feet high, and ſix Feet wide, then the Quantity of Air conveyed into each Kiln, will be 3207 Tuns in an Hour. Theſe very large Horſe-Ventilators will therefore be of ſervice, where it is needful to convey very great Quantities of Air, as here in this Caſe, and in very large Mines, *&c.* where the Air conveyed by two pair of them, as in *Fig.* 2. or 4. will be at the rate of 6414 Tuns in an Hour.

(XXIV.)

213. WHEN Hops, eſpecially wet ones, lie many Hours in a Heap, before they are laid on the Kilns to dry; they are apt to get Damage, and be diſcoloured. To prevent which Inconvenience, I fixed in the ſame Hop-Houſe two Pair of ſuch Ventilators, as are deſcribed in *Fig.* 2. to the Joice, which bear up the Floor on which the green Hops are laid; they were ſeven Feet eight Inches long, and four Feet four Inches broad, and twelve and a half Inches deep within ſide; ſo there was room for the Midriffs to move up and down a Foot: But at the other Valve end, they were twenty Inches deep, for the ſake of the larger Valves, which were each fourteen Inches long, and eight deep: One Inch of the Subſtance of the Valve-Board being left at the Top, two in the middle, and one at the Bottom, for the Valves to be nailed to and fall againſt.

214. FROM theſe Valves the Air was

conveyed in and out of the Ventilators at the rate of about 2712 Tuns in an Hour, up into a large Air-Trunk, which was fifteen Feet long, whence it run between wooden Bars nailed on the Floor, which were four Inches deep, two Inches thick, and two Inches diſtant from each other: But it had taken up much leſs Stuff, if Laths or Bars only two Inches thick had been nailed on the Floor, at the Diſtance of fifteen Inches; and acroſs them, other Laths, at two Inches diſtance, as deſcribed in *Fig.* 8. On theſe was laid a Hair-Cloth ſeventeen Feet long, and fifteen broad.

215. WHEN the Ventilators were worked, which was done by means of another Lever fixed ſideways, like a Pump-Handle to one end G or F of the long Lever, *Fig.* 2. then a Handkerchief, which was ſpread on the Hair-Cloth, was blown up ſeveral Inches; but not ſo, at thoſe Parts which were far from the great Air-Trunk Z X Y, *Fig.* 8. *viz.* becauſe the Air paſſing moſt freely through the Hair-Cloth, was all waſted, long before it reached to the farther end; for which reaſon, the Air paſſing alſo very

freely through Hops, they ought to be laid four or five times thicker, near the great Air-Trunk, than at the farther end; where the Interſtices of the Bars were cloſed up with a Board, and paſted with Paper, as were alſo all the Joints of the Boards of the Floor, to prevent the eſcaping of Air.

216. THESE Ventilators will be of uſe not only for preſerving of Hops, but alſo for drying cold, and ſweetening muſty Corn. With a view to which, a ſliding Shutter was fixed in the great Air-Trunk Z Z, to ſtop its aſcending up through the whole Hair-Cloth, in caſe one Part of it ſhall be ſufficient for the Quantity of Corn that is to be ventilated; for the leſs the Spread of the Hair-Cloth, ſo much the faſter will the Air paſs up thro' it.

(XXV.)

217. AS to Malt, being deſirous to try, what Degree of Dryneſs might be given it, by being ventilated upwards with common cold Air; *March* 22d, there being a dry North-Eaſt Wind, I procured a Pack

of undryed Malt, and put it into a Box, with a Canvas falſe Bottom, where it lay about four Inches thick. It weighed 8 Pounds, 7 Ounces and a half, and one Dram. During the firſt ſix Hours Ventilation upwards, it waſted at the rate of three Ounces and a half every two Hours; during the following fifty Hours Ventilation, it waſted nearly at the rate of one Ounce and a half every two Hours; and for the remaining laſt twelve Hours, it waſted nearly at the rate of half an Ounce every two Hours. So that in ſixty eight Hours, it waſted in all four Pounds, twelve Ounces and a half, *viz.* near $\frac{1}{3}$ of the whole weight: in which time there paſſed through the Interſtices of the Malt 244,000 Gallons of Air. This Malt when thus dryed was criſp and hard to bite, but not near ſo hard as Kiln-dryed pale Malt, which is 24 Hours in drying: on which account it did not grind ſo well, and ſome of it, tho' cloſe corked up in a Bottle, did after ſome days grow leſs hard, *viz.* probably becauſe the Moiſture near the middle diffuſed itſelf towards the dryer and harder outſide. Ale was brewed with this Malt, which was very well taſted, but not ſo pale as was expected;

which might be owing to the manner of preparing it in the Couch.

218. BUT if inſtead of cold, plenty of hot Air be conveyed upwards through Malt, it will then dry, not only much faſter, but alſo better than in the common way of drying. For when, for trial, pale Malt was dryed, on one of the abovementioned Kilns, Numb. 179. and ventilated, the firſt Kiln was dryed in eleven Hours, and a ſecond Kiln in nine Hours; during eight Hours of which nine, the drying Malt was ventilated: whereas a like Kiln of unventilated Malt was at the ſame time twenty Hours in drying, the Wind blowing very freſh; whereby, the more Air being conveyed in at the Kiln-Door, brought it on ſooner than it would otherwiſe have done; a Kiln of Pale Malt being uſually about twenty-four Hours in drying and hardening.

219. THE abovementioned Mr. *Baker* obſerved, that though the Weather was wet, and the Tiles very damp within, yet the Moiſture went off the Malt, without Sweat, with Ventilation, in much leſs Time, than in the other Kiln without Ventilation,

which ſweat very much; and conſequently the Malt which was dryed without Sweat, was much the better of the two. This Malt, he ſays, was very good, being dryed pale, and made a pale Wort of a fine Taſte. Though he obſerves, that it will not be ſo pale with a Cockle-Kiln, as when dryed in an open Kiln, with Coake, or *Welch* Coal.

220. ONE Pair of theſe Ventilators being given him, he conveyed them to *Sandwich*, and fixed them to his open Malt-Kiln there, which had no Cockle in it: where he found that by Ventilation, he could dry either pale or brown Malt, in half the uſual Time, with a ſomewhat larger Fire; for as in drying Hops, ſo in drying Malt, a greater Heat may be given when ventilated, than when not. And the pale Malt thus dryed, was paler and lower coloured, and the brown much brighter, than that which is dryed without Ventilation: Whence he concludes, that both ſorts being thus dryed without Sweat, will make better Beer, than if dryed in the uſual Way.

221. IF the Labour of working the Ventilators, during the whole time of drying,

ſhall be thought too much; he is of Opinion, that it would do good Service, if they were worked only ſo long, as the principal Damp continued among the Malt; eſpecially in a ſtill, moiſt, heavy Air.

222. He obſerved, that Malt lying cloſer together than Hops, a light Handkerchief laid on it, was not ſo ſenſibly moved by Ventilation, as when it lay ſpread on Hops.

223. The uſual Heat given to pale Malt, which is to be dryed in twenty-four Hours, is about fifty-two Degrees above freezing, which is twelve Degrees, *viz.* near one Sixth below Blood-warm: But when towards the latter End of drying, the principal Moiſture is gone off, then the Heat of the Malt is increaſed to 138 Degrees above Freezing, *viz.* more than double the Heat of Blood, which is 64 Degrees. And this Degree of Heat both hardens the Malt, ſo as to make it keep long well in Store, and alſo gives it an agreeable Sweetneſs.

224. In order to make brown Malt, a

much greater degree of Heat is given it, while it is in a damp Sweat.

(XXVI.)

225. THESE Ventilators may alſo be of uſe to thoſe who take the Hulls off from any Grains, by moiſtening them firſt: Thus whited Pepper may be well dryed; and Starch-Makers may thus dry their Starch, with warm Air from a Stove. Several kinds of Sweatmeats may be dryed thus, and alſo be preſerved very dry and free from Damp or Mouldineſs, by ventilating them now and then for a little time.

226. AND if the frowzy Air of *Larders*, *Pantreys*, and *Safes*, be now and then thus exchanged for freſh Air, it will contribute to the keeping of the Meat ſweet, and free from Muſtineſs, much the longer.

227. AND ſince a moiſt Air conduces much to the ruſting of Iron, they would probably be very ſerviceable, in keeping Arms bright in large Armories, ſuch as are in the *Tower* of *London*.

228. THE Expence of Trial with theſe Ventilators in theſe Caſes, is inconſiderable, and the Benefit propoſed great. They will doubtleſs alſo be of ſervice in many other Inſtances, which do not occur to me, but may hereafter be thought of, and applied by others to be ſerviceable to them in their ſeveral Profeſſions.

(XXVII.)

229. IF I had had Opportunities to make more Trials in ſeveral of the Things here propoſed, I could have given a fuller and more ſatisfactory Account of them. It were therefore to be wiſhed, that whatever Succeſs or Difficulties occur on trial, as alſo what further Improvements ſhall hereafter be made herein, were from time to time communicated to the World.

230. IT will be a great Satiſfaction to me, if theſe Things ſhall prove beneficial to Mankind; eſpecially to thoſe numerous, uſeful and valuable Perſons, *who occupy their Buſineſs in great Waters:* Whom I have laboured

in many ways to do the beſt Service I could. And oh! that I could prevail with them, to be in earneſt ſo true to their own Intereſt, as not to deſtroy their Health and ſhorten their Lives, by the intemperate Uſe of diſtilled ſpirituous Liquors, ſuch as Brandy, Rum, Arrack, *&c.* The Health of many of them is impaired, and dangerous Sickneſſes are often occaſioned, by the very noxious rancid cloſe Air in Ships: But the Number of thoſe, who loſe their Lives by this, and all other Dangers and Difficulties they are expoſed to, is ſmall in compariſon of the vaſt Multitudes that are deſtroyed by theſe pernicious Liquors, eſpecially in hot Climates. And will not the yearly Deſtruction of Thouſands, nay of Millions all over the World, deter them from it? Will not the ſtrong natural Deſire they have to *live long and ſee good* and healthy *Days*, prevail with them to avoid this Bane of Mankind? Will they, in ſpite of all theſe Arguments, be their own Executioners, and conſign themſelves over, not only to preſent, but eternal Death alſo?

ON

SHIP-WORMS.

(XXVIII.)

231. IT may not be improper here to mention a Propoſal, which I have long thought might probably prove of very great Service to Shipping: And that is, to have a ſhort Account drawn up and publiſhed of the principal Methods, that are now in uſe, or that have from time to time been propoſed and tryed; for preventing the Planks and Timbers of Ships being eaten by Worms. This ſeems to me, to be the likelieſt Way to find out a more effectual and cheaper Remedy than is yet known. Were I to engage in the Reſearch, which I have no Intention to do; I ſhould, in the firſt place, make it my Endeavour, to know what had hitherto been attempted; and the Reaſons why thoſe ſeveral Attempts had proved unſucceſsful:

ſucceſsful: for I have frequently found, that the knowing what will not do, has led me to the thing ſought after. The Mind unaſſiſted, can view but one Thing at a time; but when all the ſeveral Attempts are laid before it, in one View, they may give riſe to new Hints; or various Combinations, of ſome of thoſe Things which alone have proved unſucceſsful, may perhaps be more effectual.

232. AND beſides, by ſetting the Thing in a clear and full View, to the World; it will very much increaſe the Probability of Succeſs: for as Men have very different Views of Things according to their different Talents, or Profeſſions; ſo that what may never be diſcovered by very ingenious Men in one Profeſſion, may yet haply be done by others. Thus, if Artizans of different Profeſſions would conſult each other, and if thoſe who have a more inlarged Knowledge of Nature would conſult Artizans, and Artizans them, and each openly and candidly communicate Notices to each other, there would doubtleſs by this means

be many uſeful Diſcoveries made from time to time, to the great Benefit of Mankind.

233. I CANNOT therefore forbear heartily to recommend the Thing not only to my own Country, but to all Maritime Nations, that they would join in communicating their ſeveral Attempts in this way; and if withal a Reward was annexed, I believe a much leſs Reward than what is offered for the Diſcovery of the Longitude, would ſpur People on to engage in a Reſearch; which, as it is of vaſtly more Importance to Navigation, than the Diſcovery of the Longitude; ſo, for our Encouragement, there is a much greater Probability of Succeſs in it. As ſeveral ingenious Perſons have made conſiderable uſeful Advances, in that leſs important, and probably more difficult Diſcovery; ſo there is good reaſon to think that very uſeful Improvements would in a little Time be made in this.

234. I SHALL only mention, that, from ſome Obſervations which I have made, it is to be feared, that oily unctuous Things are not likely to penetrate deep into Oak,

which has a watry Sap: But, as it is well known to Oilmen, it will penetrate far into Fire, which has an oily unctuous Sap, Oil and Oil readily uniting; inſomuch, that they are obliged to ſet Veſſels under the Fir Heads of Oil-Casks, to receive the Droppings of Oil which ouze thro' the whole Subſtance of the Wood, tho' thick. And they further obſerve, that Oil gives the Fir ſuch a ſurprizing Degree of Toughneſs, as will turn the Edge of the Adze or Ax, in cutting it: Now if Oil could be made thus to penetrate into the Subſtance of the Fir-Boards with which Ships are ſheathed; and there were mixed with the Oil, ſome proper Thing that were diſagreeable to the Worms, then this would preſerve the Ships: But in caſe that neither ſuch a Mixture nor the Oil could be made to penetrate deep into the Fir, yet as frequent oiling would give great Toughneſs and Dureableneſs to the Sheathing; ſo ſuch Sheathing would ſo much the longer preſerve ſuch a *Paying* under it, from being rubbed off, as ſhould be found impenetrable to the Worms; and that ſuch Payings may be had, there is no doubt; but the great Difficulty has hitherto been, as I am informed, to preſerve ſuch Paying from being rubbed off.

235. As Verdigreaſe is moſt diſagreeable and deſtructive to all Animals whatſoever; ſo I believe that a very ſmall Proportion of it in any Paying whatever, would do good Service. I have found, that a thirtieth Part of it melted with Tallow, has given the Tallow a conſiderable degree of Greenneſs: and alſo that Sea-Water will not waſh it out of the Tallow, even tho' it has laid long in it, and coarſe Verdigreaſe is not dear.

236. The great Damage that is done to Shipping by Worms, as it has doubtleſs hitherto put Men on trying from time to time, all imaginable Means to prevent it; ſo ſhould it urge us on, ſtill to perſevere, and not deſpair of Succeſs, in ſo important an Affair.

FINIS.

A GENERAL

INDEX

OF THE

Matters contained in this Book.

A.

AIR, *a Tun weighs* 300 *Grains*, 3.
  The Quantity we breathe in 24 *Hours*, 3.
The Quantity conveyed by Ventilators, 12, 30, 148.
Its Velocity eſtimated, 12, &c. 30.
In Ships unwholeſome, 32.
Bad, its pernicious Effects, 42, *to* 50.
Its ſuffocating Power to prove, 65.
Dry, beſt to Ventilate Corn, 98, &c. 123.
Dry, its Effect on Reſpiration, 106.
One of the great Inſtruments of Nature, 126.
Is electrical, 127.

Air,

Air, *hot, to convey in plenty*, 140.
Armories, *to be ventilated*, 158.

B.

Barracks, *to ventilate*, 22.
Beer, *hot, to cool by Ventilation*, 128.
Bins, *propoſed to preſerve Peaſe in Ships*, 60, 61.
  By them much Stowage ſaved, 63.
Bottles, *to clean*, 70.
Bread, *in Ships to preſerve*, 59, 69.
Breath, *draws Infections in*, 40.
  The Quantity carried off by it, 43.
  How incommoded, 44, 47.
  In cloſe Rooms, 48.
Brimſtone, *its Fumes cure Infection*, 51, 52.
Bugs, *to deſtroy*, 53, 54.

C.

Casks, *muſty, to ſweeten*, 70.
Churches, *their Air to refreſh*, 48.
Cleanlineſs, *withal recommended*, 50.
Corn, *in Ships to ventilate*, 33, 91, 92.
  To preſerve, 81, &c.
  How much it ſhrinks in Meaſure on ſhaking, 90.
  To fumigate, 93.
  Fumigated has no ill Savour, 96.
  Waſhed, ventilated dry, 97, 102, &c.
  Muſty to ſweeten, 105.

Corn,

Corn, *in Graineries and Ships to ventilate*, 111.
  In Mows to dry, 115.

D.

Damps, *their kinds in Mines*, 21.
A Diving *Inſtrument deſcribed*, 66.
Drams, *their pernicious Effects*, 112.

F.

Fir, *imbibes Oil*, 164.
Fumigation, *propoſed to cure Ships and Houſes of Infection*, 51, 52.
  To preſerve Bread and Peaſe in Ships, 61, 62.
  Of Corn, 93.
  Gives Corn no ill Savour, 96.

G.

Goals, *to ventilate*, 22, 50.
  Diſtempers, 45.
Graineries, *how to prepare*, 82, 91, &c.
  To ventilate now and then, 111.
  The great Uſe of ventilating them, 112.
Green-Houſes, *to ventilate*, 24.
Gun-Powder, *kept dry by Ventilation*, 64, 124, 125.
  To dry, 119.

H.

Hops, *Kilns to order*, 138.
  Ventilators, 129, 144.
  To ventilate, 16, 129.
  Ventilated, 136, &c.

Hops, *their different Degrees of Heat in drying*, 141.

Horſes, *in Ships to preſerve*, 33.

Hoſpital-Ships, *to ventilate*, 33.

Hoſpitals, *to ventilate*, 23, 50.

I.

Infants, *hurt by Swathing*, 77.

Their Skulls ought not to be compreſſed, 78.

Infection, *enters by the Breath*, 40.

To cure by Fumigation, 51, 52.

L.

Larders, *to be ventilated*, 158.

Leakages, *to ſtop in Ships*, 67.

M.

Magazines, *to ventilate*, 16, 20, 124.

Malt, *to ventilate*, 16.

Ventilators, 129.

Kilns to order, 138.

Dryed with cold Air, 153.

With hot Air, 155.

Mills, *will eaſily ventilate Corn*, 108.

Will winnow Corn, 110.

Mines, *to ventilate*, 16, 17, 20.

Their ſeveral kinds of Damps, 21.

Mows, *of Corn to dry*, 115.

Muſtineſs, *to cure*, 70.

O.

Oak, *will not imbibe Oil*, 163.
Oil, *will not ſoak into Oak*, 163.

P.

Pantreys, *to be ventilated*, 158.
Peaſe, *in Ships to preſerve*, 60, 61, 62.
Pepper, *white, to ventilate*, 158.
Perſpiration, *its Quantity*, 32, 42, 43.
Its Matter noxious, 42.
Plague, *its Infection to cure*, 54.

R.

Regulator, *deſcribed*, 5.
Reſpiration, *the Quantity carried off by it*, 43.
How affected by a dry Air, 106.
Reſpirator, *its Deſcription and Uſe*, 66.
Ricks, *of Corn, to dry*, 115.
Rivers, *why they freeze firſt at bottom*, 72.
Their upper Water deſcends towards the bottom, 72.
Rooms, *cloſe, the Inconveniencies of them*, 48.

S.

Safes, *to be ventilated*, 158.
Sea-Water, *deſcends and aſcends, at great Depths*, 73.
Ships, *to ventilate*, 24, &c.

Ships, *Hoſpital, to ventilate*, 33.
  New, unhealthy, 33.
  Preſerved by Ventilation, 34.
  To be much ventilated, 38.
  To fumigate, 51, *to* 54.
  Their Leakages to ſtop, 67, 68.
  Worms to deſtroy, 161.
  Sheathing to make durable, 164.
Smoke, *a Room cleared of it by Ventilation*, 16, 59.
Spirits, *diſtilled, their pernicious Effects*, 112, 160.
Swathing, *bad for Infants*, 76.

T.

Tar, *Fumigation with it*, 52.

U.

Valves, *deſcribed*, 9.
Ventilators, *large, their Deſcription*, 3, &c.
  To be moved by a Horſe or Water, 16, 17.
  Double or treble, 18.
  Upright deſcribed, 19.
  Their Uſefulneſs in Ships, 38, *to* 49.
  Small deſcribed, 56.
  Their Uſes, 59, &c. 65, 69.
  For Corn, 100, 151.
  To be fixed in Mills, 108.
  Will carry off noxious Vapours, 127.
  Will dry and preſerve Wool, Feathers, 128.

Ventilators, *will refreſh in hot Climates*, 128.
  For Hops and Malt, 129, 151.
  How to move with Horſe or Mill, 144, &c.
Ventilation, *its Labour in Ships, not great*, 35.
  Its Importance, 39, 41.
  Its Uſe in cooling Beer, 128.
Verdigreaſe, *to prevent Worms*, 165.
Vermine, *to deſtroy*, 55.
Vinegar, *its Uſe in Ships*, 45.
  Its Uſe in ſick Chambers, 46.

W.

Water, *ſtinking to ſweeten*, 69, &c.
  Putrid or ſtinking, will clean Bottles, and ſweeten muſty Casks, 70.
Wells, *to ventilate*, 20.
  Of Ships to ventilate, 65.
  To go with ſafety into them, 67.
Wheat, *the Vacancy between its Grains*, 85.
  One Tenth heavier than Water, 85.
  Waſhed and Kiln-dryed, not good, 97.
  Ventilated good, 97.
  Forty Buſhels, are equal to fifty and a half Cubick Feet, 108.
  The Quantity of its Moiſture when waſhed, 109.
  Cold, will ſoon be dryed, 110.
Wind-ſails, *their Defects*, 31, 38.
Work-Houſes, *to ventilate*, 22, 50.
Worms, *of Ships, to prevent*, 161, *to* 165.

THE END.

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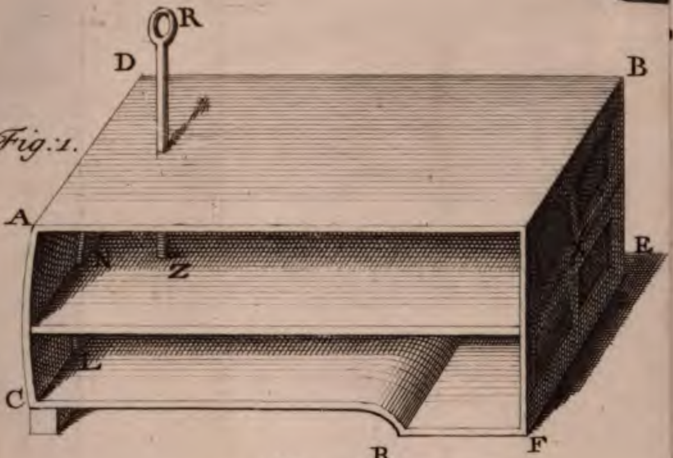

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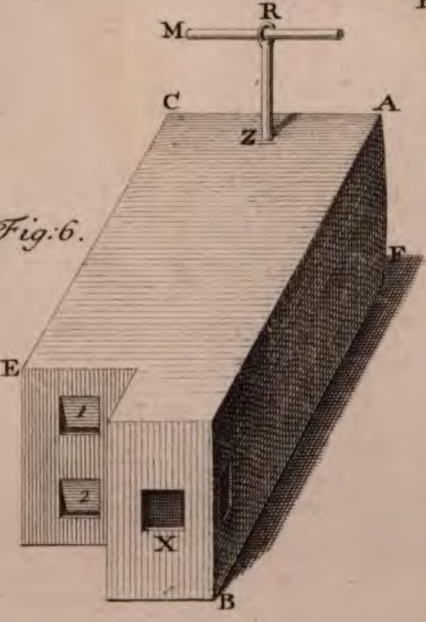

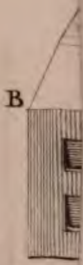

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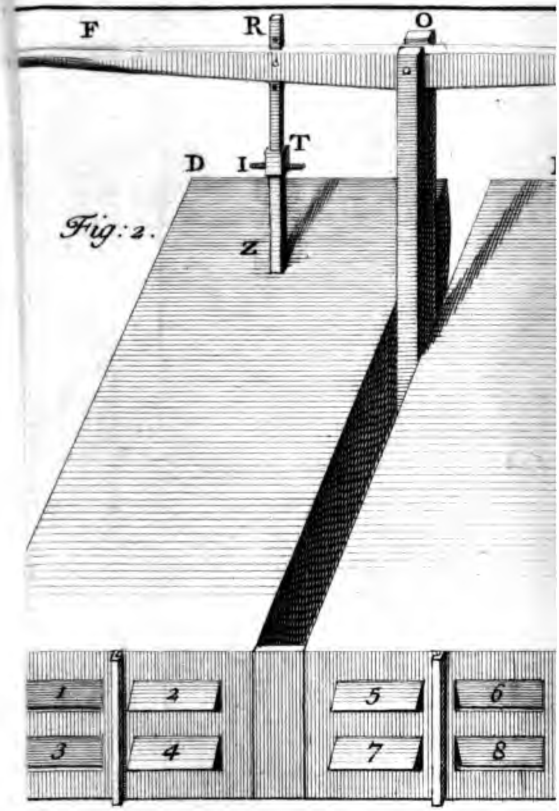

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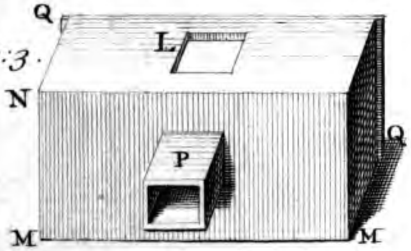

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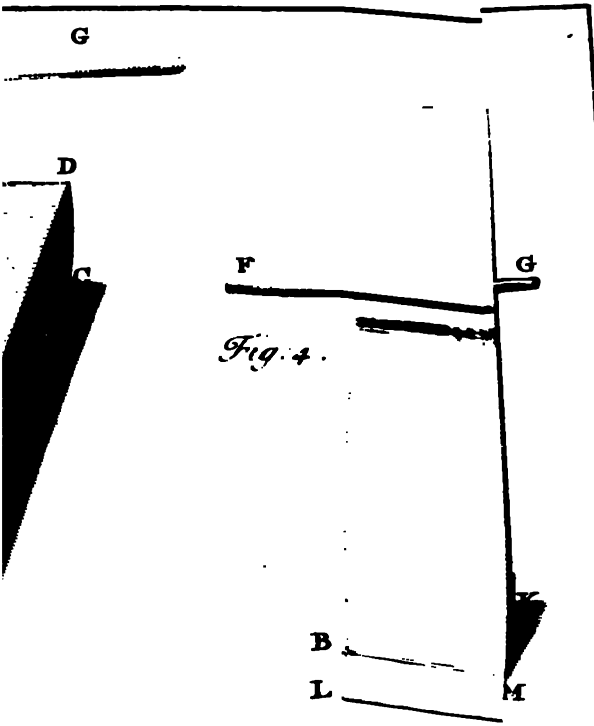

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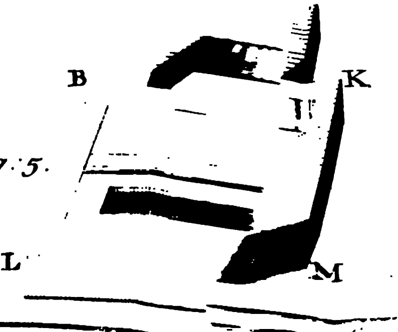

Fig. 5.

Sc.

Fig: 11.